

CONTRIBUTIONS FROM THE OBSERVATORY OF
COLUMBIA UNIVERSITY—No. 24

RUTHERFORD PHOTOGRAPHS
OF THE
STELLAR CLUSTERS

$\bar{h}$ AND χ PERSEI

BY
ANNE SEWELL YOUNG

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY IN THE FACULTY OF
PURE SCIENCE, COLUMBIA UNIVERSITY

NEW YORK
1906

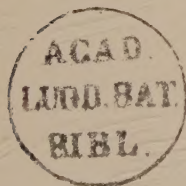
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Attention is called to the Lists of Errata in former Contributions from the Observatory, to be found in Publication 19, p. 68, and on p. 74 of the present publication.

PREFATORY NOTE.

The present memoir contains further results derived from the collection of Rutherford photographs belonging to Columbia University. The measures were made at Columbia by Miss F. E. Harpham, assisted by Misses H. L. Davis, Eudora Magill and Mary Tarbox, who have also aided in the routine work of reduction. The author has departed to some extent from the methods of our former publications, notably in the formation of a "mean" plate to be used as a standard for the reduction and inter-comparison of the individual photographs.

The expenses connected with this publication have been met by Rutherford Stuyvesant, Esq., of New York.

HAROLD JACOBY,
*Rutherford Professor of Astronomy and
Director of the Observatory.*

COLUMBIA UNIVERSITY,
September, 1906.

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I. DESCRIPTION OF THE PLATES.

The stellar clusters h and χ *Persei* lie about half-way between the two stars γ *Persei* and δ *Cassiopeiæ*. On a clear moonless night they appear to the naked eye as a single hazy patch of light. A telescope of low power shows a magnificent field of stars ranging from the sixth magnitude to the limit of visibility. There are two very evident centers of condensation distant from each other about twenty minutes of arc. The preceding cluster is known as h *Persei*, the other as χ *Persei*.

Both stellar clusters are found upon the photographs considered here. These were made by Rutherford in his usual manner. Each plate was exposed twice for about six minutes with an interval of a few seconds between the exposures, during which time the driving-clock was stopped, the adjustment of the plate being undisturbed. Thus we find upon each plate two complete pictures of the group, the two images of each star being separated by about one millimeter. A third and shorter exposure was made in the same way after an interval of about three minutes, so that there are faint images of the brightest stars about thirty-five millimeters to the west of their principal images. This third impression was intended by Rutherford to serve as a means of determining the orientation constant of the plate, but we have used it only for the adjustment of the plate in the measuring machine. It has been shown by Schlesinger¹ that the orientation constant obtained in this way is not sufficiently accurate for our purpose.

Rutherford used as his central, or guiding star B. D. 56° 530, and so adjusted the plate that the image of this star would fall very near its center, the "center" of the plate being defined as that point where a perpendicular from the optical center of the object glass would pierce the plate.

The first five plates were inferior to the others, and although

¹ The *Præsepe* Group, *Contributions of the Columbia University Observatory*, No. 15, p. 282.

they had been measured, it was decided not to include the results in the final catalogue. They will be considered in the discussion later on. Measures of stars whose images were not well-defined were also rejected.

The data for all plates are given in Table I; excepting the zenith distance, all were taken directly from Rutherford's record pencilled upon the original negatives.

TABLE I.—PHOTOGRAPHS OF PERSEUS.

OBSERVATORY OF L. M. RUTHERFURD, NEW YORK.

Lat. $40^{\circ} 43' 48''.5$.

Long. $4^h 55^m 56^s.62$ W.

No.	Date.	Sidereal Time.	Bar.	Thermometer.			Focus.	Z. D.
				Att.	Ext.	Tel.		
		h m s						$^{\circ}$
7	1870 Mar. 24	7 42 25	30.380	36°	32°	—	—	53.5
8	1870 Mar. 24	8 17 52	30.380	36	32	38	—	58.0
9	1870 Mar. 24	8 51 22	30.380	36	32	38	—	62.0
10	1870 Mar. 25	7 29 30	30.454	41	36	—	—	51.8
11	1870 Mar. 25	8 13 10	30.454	41	36	43	—	57.4
12	1873 Dec. 15	0 54 22	30.350	40	40	40	7.8	20.1
13	1873 Dec. 18	0 42 22	30.052	42	41	43	7.8	21.3
14	1873 Dec. 21	0 46 18	30.392	29	27	30	7.9	20.9
15	1874 Jan. 18	3 37 32	30.408	31	30	32	7.65	21.2
16	1874 Jan. 18	4 14 45	30.408	31	30	32	7.65	25.6
17	1874 Jan. 18	4 53 48	30.408	31	30	32	7.65	30.7
18	1874 Oct. 14	21 47 2	30.376	43	40	45	7.7	44.3
19	1874 Oct. 14	22 27 2	30.376	43	40	45	7.7	38.8
20	1874 Oct. 14	23 9 8	30.376	43	40	45	7.7	33.1
21	1874 Oct. 15	23 13 38	30.328	51	49	52	7.7	32.5
22	1874 Nov. 6	23 34 42	30.250	56	57	57	7.8	29.6
23	1874 Nov. 6	0 34 48	30.250	56	57	57	7.8	23.7

The "sidereal time" is the mean of the four instants of beginning and end for the two principal exposures. The seventh column gives the readings of a thermometer attached to the telescope tube, and the eighth gives the readings of a micrometer head attached to the eye-end of the telescope, indicating the position of the plate-holder. The last column gives the zenith distance of the central star at the time of exposure.

II. MEASUREMENT OF THE PLATES.

The plates were measured in the spring of 1901 by Miss F. E. Harpham, assisted by Misses Magill, Davis and Tarbox. Plates 12, 13, 14 and 23 were measured with the older Repsold Measuring Machine, hereafter designated as Machine No. 1, while a newer machine, known as Machine No. 2, was used for the other plates. Both machines correspond very closely to the description given by Scheiner¹ of a similar instrument in use at the Leyden Observatory.

The micrometer microscope is so mounted that by rotation through a small angle it may be directed toward the scale, and bisections of the star and division lines of the scale are made with the same micrometer. This microscope may be moved in a direction parallel to the scale, while the plate-holder slides upon an accurately straight steel cylinder far enough to allow the entire plate to pass under the frame to which the microscope is attached. By a combination of these two motions at right angles to each other, any part of the plate may be brought into the field of the micrometer microscope.

This microscope is provided with both horizontal and vertical screws, but only the horizontal screw was used in the measures. Two revolutions of this screw correspond to one millimeter of the scale. The micrometer head is divided into one hundred parts, so that by estimating tenths of a division, the scale may be read to half-microns (0.0005 mm.). As one millimeter upon the Rutherford plates is equivalent to nearly 53'', this corresponds to about 0.''026.

The circular plate-holder may be rotated through any angle desired. It is provided with a circle graduated to 10' of arc and read to seconds by means of micrometer microscopes. The circle is centered when the lines of the graduation are parallel to the micrometer threads and both microscopes read alike. The reading of the circle was always taken at the begin-

¹ Die Photographie der Gestirne, p. 148.

ning and end of a series of measures, so that any change in the position of the plate-holder might be noted.

Each plate was measured in four positions, designated as " x direct," " x reversed," " y direct," " y reversed." If the plate be placed in the holder with the trails down, and the holder be revolved until the imaginary line joining the central star and its trail is parallel to the cylinder, the declination circle of the central star will be very nearly parallel to the scale. If then the holder be rotated through an angle of 90° in a counter-clockwise direction, right ascensions will increase toward the left, and the plate is in the position known as " x direct." Continuing the rotation 90° , we have " y direct," and so on.

In the measurement of these plates, this orientation was corrected for the curvature of the diurnal circle of the star.¹ If x'' be the amount of this correction expressed in seconds of arc, we have the equation,

$$x'' = \frac{1}{2}s'' \tan \delta,$$

where s'' is the length of the trail expressed in seconds, and δ is the declination of the central star. For these plates the sign of the correction was always negative; i. e., the plate-holder was rotated so as to decrease the circle-reading by the amount of the correction.

Two observers were engaged in the measures of each day, one recording while the other measured, but each measuring the coördinates of both east and west images of every star in both direct and reversed positions of the plate. Thus each coördinate is the mean of eight measures, and by the combination of the measures in the direct and reversed positions, the effect of personal equation is very largely eliminated.

For one half the readings upon each star the micrometer screw was set at $10^7.0$, for the other half at $10^7.5$, so as to eliminate the effect of possible periodic errors of the screw.

The probable error of a measured coördinate was computed for one of the plates (No. 16), using the stars found on all plates

¹See *Contrib. Col. Univ. Obs.*, No. 16, p. 402.

and combining the measures in the following manner so as to eliminate personality.

Let

A_d and B_d = the readings of observers A and B respectively
for plate direct ;

A_r and B_r = the corresponding readings for plate reversed ;

v = the difference between the measures of the two
observers for any one star ;

r = the probable error of a measured coördinate.

Then

$$(A_d - B_d) - (A_r - B_r) = 2v,$$

and

$$r = \pm \frac{0.6745}{2} \sqrt{\frac{[vv]}{n}}.$$

The value of r for an x coördinate was found to be $\pm 0''.035$;
for y it is $\pm 0''.033$.

As the results of the inter-comparison of plates given in
Table V would indicate that those used in the final catalogue
were about equally good, it is safe to assume that this repre-
sents fairly the accuracy of all the measures.

III. INSTRUMENTAL CORRECTIONS.

Certain instrumental corrections must be applied to the measures before we obtain the corrected coördinates given in Table III.

These are :

1. **Non-Periodic Errors of the Screw.** — As was stated before, only the horizontal micrometer screw was used in the measures. The corrections for this screw for Machine No. 1 have already been published.¹ A similar investigation² of the non-periodic errors of the horizontal screw of Machine No. 2 gave the following corrections to be added to the observed readings of the micrometer head.

Readings of Micrometer.	Correction in mm.
r	
5.0	0.0000
6.0	+0.0004
7.0	-0.0001
8.0	-0.0007
9.0	-0.0006
10.0	-0.0015
11.0	-0.0019
12.0	-0.0023
13.0	-0.0022
14.0	-0.0022
15.0	0.0000

It will be noticed that the correction progresses uniformly for that part of the screw used in making the measures, *viz.*, from 10^r.0 to 12^r.0. For convenience an auxiliary table was constructed giving the value of the correction for every tenth of a revolution.

The periodic errors of the screw were eliminated sufficiently by the method of making the measures, as already explained.

2. **Correction for Runs.** — This correction was determined each day at the beginning and end of a series of measures, the

¹ *Contrib. Col. Univ. Obs.*, No. 15, p. 218.

² For method of determining these corrections, see *On the Permanence of the Rutherford Photographic Plates*, by H. Jacoby. *Contrib. Col. Univ. Obs.*, No. 11.

mean of the two corrections being adopted for the series. Lines 60 and 65 of the scale were used, as these two lines were known to have very nearly the same division errors. For most of the measures the microscope was adjusted so as to make this correction zero; when any error was found to exist, it was combined with the correction for the non-periodic errors of the screw.

3. **Division Errors of the Scale.** — The division errors of Scale A of Machine No. 1 were published in Schlesinger's paper on the Præsepe Cluster,¹ and need not be repeated here. The division errors of Scale C of Machine No. 2 will be found in Table II. These corrections² applied to the readings of the scale reduce them to what they would have been had the successive divisions been distant from each other exactly $\frac{1}{180}$ th of the total length of the scale.

4. **Rotation Corrections.** — A careful reading of the circle was made at the beginning and end of the measures in each position of the plate. Whenever the readings for "*x* direct," "*y* direct," etc., do not differ from each other by exactly 90° , a correction must be applied for rotation of the axes of coördinates.

Let

D = the number of seconds adopted for the circle readings of a given plate;

$D + r$ = the reading for one position of the plate;

x and y = the differences between the corrected scale readings for the given star and the center, positive when the α and δ of the star exceed those of the center;

x' and y' = these coördinates corrected for rotation of the axes.

¹ *Contrib. Col. Univ. Obs.*, No. 15, p. 217.

² For method of determining these corrections, see On the Determination of the Division Errors of a Straight Scale, by H. Jacoby. *American Journal of Science*, Vol. I, 1896, p. 333. See also Ueber die Untersuchungen der Scalen eines Heliometers, by G. Lorentzen, *Astron. Nach.*, 3134-35, 3236.

Then

$$\begin{aligned}x' &= x \cos r + y \sin r, \\y' &= -x \sin r + y \cos r.\end{aligned}$$

As r is always a small angle, we may write

$$\begin{aligned}x' &= x + yr \sin 1'', \\y' &= y - xr \sin 1'',\end{aligned}$$

in which r is expressed in seconds of arc.

To the measured x 's the correction $+ yr \sin 1''$ must be applied, to the measured y 's, $- xr \sin 1''$.

These corrections for instrumental errors have been applied to the measures, giving the "Corrected Coördinates" of Table III.

TABLE II.—DIVISION ERRORS OF SCALE C.

MEASURING MACHINE No. 2.

Line.	Correction in mm.	Line.	Correction in mm.	Line.	Correction in mm.
0	0.0000	44	-0.0004	88	-0.0002
1	-0.0006	45	-0.0014	89	-0.0011
2	-0.0007	46	-0.0020	90	0.0000
3	-0.0006	47	-0.0018	91	-0.0004
4	-0.0008	48	-0.0018	92	+0.0001
5	-0.0012	49	-0.0018	93	-0.0001
6	-0.0018	50	-0.0030	94	-0.0019
7	-0.0009	51	-0.0022	95	-0.0018
8	-0.0019	52	-0.0023	96	-0.0006
9	-0.0014	53	-0.0030	97	-0.0008
10	-0.0007	54	-0.0024	98	-0.0001
11	-0.0017	55	-0.0022	99	-0.0008
12	-0.0004	56	-0.0027	100	+0.0003
13	-0.0012	57	-0.0024	101	+0.0002
14	+0.0003	58	-0.0036	102	+0.0003
15	-0.0008	59	-0.0028	103	+0.0004
16	-0.0006	60	-0.0038	104	0.0000
17	-0.0010	61	-0.0036	105	+0.0008
18	0.0000	62	-0.0037	106	+0.0004
19	-0.0010	63	-0.0042	107	+0.0012
20	-0.0008	64	-0.0028	108	+0.0007
21	-0.0013	65	-0.0036	109	+0.0013
22	-0.0013	66	-0.0036	110	+0.0008
23	-0.0008	67	-0.0038	111	+0.0008
24	-0.0010	68	-0.0025	112	+0.0016
25	-0.0004	69	-0.0026	113	+0.0012
26	-0.0006	70	-0.0026	114	+0.0004
27	+0.0010	71	-0.0020	115	-0.0001
28	0.0000	72	-0.0020	116	+0.0004
29	0.0000	73	-0.0027	117	+0.0004
30	0.0000	74	-0.0020	118	+0.0009
31	-0.0001	75	-0.0022	119	+0.0004
32	-0.0002	76	-0.0019	120	+0.0008
33	-0.0002	77	-0.0007	121	+0.0005
34	-0.0006	78	-0.0008	122	+0.0006
35	-0.0012	79	-0.0008	123	+0.0006
36	+0.0004	80	-0.0013	124	+0.0003
37	-0.0002	81	-0.0016	125	-0.0004
38	-0.0003	82	-0.0016	126	+0.0001
39	-0.0008	83	-0.0010	127	+0.0007
40	-0.0008	84	-0.0014	128	0.0000
41	-0.0016	85	-0.0013	129	+0.0003
42	-0.0017	86	-0.0012	130	0.0000
43	-0.0014	87	-0.0009		

TABLE III.—CORRECTED COÖRDINATES.

PLATE 12.					
Star.	X	Y	Star.	X	Y
I	-50.2734	+23.2780	66	-0.0145	-2.7577
3	-38.0657	-16.7282	67	0.0000	0.0000
4	-32.9767	+40.2072	69	+2.0090	-6.1540
5	-31.7344	+16.8876	70	+2.1002	-2.0784
6	-29.1953	+38.9592	73	+3.7629	+22.7157
7	-27.8964	+30.1932	74	+4.0879	-5.1996
9	-23.6723	-29.5564	75	+4.6554	-30.7558
10	-22.6392	-9.7128	78	+6.3255	+10.2333
11	-21.8203	-7.9483	79	+8.1036	-39.1769
12	-21.5698	-20.4942	80	+8.3369	+20.3438
13	-20.9314	-2.8440	81	+9.6435	-29.0592
14	-20.8067	-30.8360	82	+9.5700	-4.6622
17	-19.8294	-13.8305	85	+12.8979	+9.9082
18	-19.1761	-27.3629	86	+14.7953	+19.8394
19	-18.0913	-18.6255	87	+15.5221	-16.3184
20	-16.3982	+13.2304	88	+17.4739	+0.1222
21	-15.1551	-5.8384	89	+18.2146	-23.6846
22	-14.5939	+1.9005	90	+18.3194	-20.3534
24	-13.2882	+15.8330	91	+18.5138	-21.1468
25	-13.1808	-36.0525	92	+18.9470	-1.3172
26	-12.8881	-5.4960	94	+20.7423	+27.5450
27	-11.9582	+49.5742	95	+21.5950	+9.0365
28	-10.8394	+23.4982	97	+23.0273	-2.5473
29	-10.2256	-47.0479	99	+23.7658	+15.2193
30	-9.4142	+12.7741	102	+24.7600	-17.5342
31	-9.2438	+21.8138	103	+24.6996	+5.4638
32	-9.0498	+44.0161	107	+25.6460	-1.1840
34	-8.7782	+2.8816	108	+25.7120	-1.7050
35	-8.4218	+4.5212	109	+25.9903	-1.4940
36	-8.3407	-21.7767	110	+26.6313	-4.8837
37	-7.9977	-19.2879	111	+27.1354	-43.4088
38	-7.9848	-41.0252	112	+26.7443	-3.4198
39	-7.7138	-10.9099	113	+26.9037	-2.5455
40	-7.0703	+2.5815	115	+27.0894	-3.0325
42	-6.7752	-1.3250	116	+27.9526	+7.5130
43	-6.7360	+26.4137	118	+28.3103	-2.5818
44	-6.3655	+2.7659	119	+28.8185	+8.4125
45	-5.7827	-20.2978	120	+30.0358	+3.2150
46	-5.1248	-4.7123	121	+31.2455	-5.3442
47	-4.7718	-54.0238	122	+32.3521	-4.9763
48	-4.6180	-27.8128	123	+32.5604	+23.9518
49	-4.0824	+7.8625	124	+33.0682	-0.3912
50	-4.0028	-2.3672	125	+35.5984	+5.8334
51	-3.9920	+4.7823	127	+34.5084	-9.9154
52	-3.9225	-6.9848	128	+34.4033	+15.5084
53	-3.7077	-4.9456	130	+35.9733	+21.3432
54	-3.0666	-2.0645	131	+36.5184	+0.9437
60	-1.4284	-2.3153	133	+39.0188	-20.6175
61	-1.1270	-2.9514	136	+40.9985	-18.7878
63	-0.5223	-2.8716	140	+43.9096	+13.5334
64	-0.5082	-2.6356	143	+49.8542	+4.3865
65	-0.3825	-9.8249	145	+50.3980	+21.2502

TABLE III.—CORRECTED COÖRDINATES.—*Continued.*

PLATE 13.					
Star.	X	Y	Star.	X	Y
1	-50.2661	+23.2932	57	- 2.0986	- 1.6298
3	-38.0641	-16.7200	60	- 1.4254	- 2.3140
4	-32.9660	+40.2119	61	- 1.1117	- 2.9508
5	-31.7319	+16.8989	62	- 0.6930	- 2.3267
6	-29.1807	+38.9649	63	- 0.5192	- 2.8736
8	-25.3402	-46.5313	64	- 0.5019	- 2.6347
9	-23.6758	-29.5520	65	- 0.3734	- 9.8231
10	-22.6389	- 9.7080	67	0.0000	0.0000
11	-21.8242	- 7.9472	69	+ 2.0196	- 6.1545
12	-21.5686	-20.4836	70	+ 2.1064	- 2.0782
13	-20.9246	- 2.8370	71	+ 3.6383	+34.3924
14	-20.8138	-30.8340	72	+ 3.7670	+ 6.9320
15	-20.5147	- 4.9130	73	+ 3.7681	+22.7124
17	-19.8254	-13.8233	74	+ 4.0946	- 5.1996
18	-19.1795	-27.3567	75	+ 4.6532	-30.7624
19	-18.0886	-18.6232	76	+ 4.5978	-12.8531
20	-16.3904	+13.2319	77	+ 5.8092	-54.0194
21	-15.1476	- 5.8380	78	+ 6.3298	+10.2339
22	-14.5851	+ 1.9024	79	+ 8.1047	-39.1848
23	-13.5829	-18.4564	81	+ 9.6389	-29.0642
24	-13.2784	+15.8419	82	+ 9.5761	- 4.6603
25	-13.1916	-36.0503	83	+12.2777	+43.6078
26	-12.8829	- 5.4954	84	+13.3480	-56.9114
27	-11.9481	+49.5727	85	+12.9042	+ 9.9094
28	-10.8348	+23.5003	86	+14.8040	+19.8446
29	-10.2312	-47.0462	87	+15.5217	-16.3201
30	- 9.4088	+12.7792	88	+17.4800	+ 0.1212
31	- 9.2331	+21.8171	89	+18.2114	-23.6835
32	- 9.0353	+44.0176	90	+18.3208	-20.3530
33	- 9.0512	+ 0.0276	91	+18.5179	-21.1506
34	- 9.7677	+ 2.5838	92	+18.9505	- 1.3130
36	- 8.3374	-21.7696	93	+18.8852	+ 9.6374
37	- 7.9941	-19.2885	94	+20.7435	+27.5326
38	- 7.9893	-41.0271	95	+21.3990	+ 9.0304
39	- 7.7156	-10.9080	97	+23.0344	- 2.5485
40	- 7.0629	+ 2.5832	98	+23.6739	-13.4216
41	- 6.9084	+13.3465	99	+23.7724	+15.2156
42	- 6.7692	- 1.3244	100	+24.4365	+ 0.2399
43	- 6.7229	+26.4113	101	+24.9438	-39.9546
44	- 6.3552	+ 2.7731	102	+24.7582	-17.5330
45	- 5.7839	-20.2987	103	+24.7042	+ 5.4582
46	- 5.1165	- 4.7092	107	+25.6468	- 1.1857
47	- 4.7830	-54.0268	108	+25.7122	- 1.7054
48	- 4.6210	-27.8097	109	+25.9808	- 1.5004
49	- 4.0761	+ 7.8640	110	+26.6382	- 4.8829
50	- 3.9964	- 2.3630	111	+27.1305	-43.4126
51	- 3.9882	+ 4.7849	112	+26.7452	- 3.4208
52	- 3.9168	- 6.9858	113	+26.9113	- 2.5454
53	- 3.7080	- 4.9478	114	+27.4786	-37.9528
54	- 3.0670	- 2.0609	115	+27.0935	- 3.0370

TABLE III.—CORRECTED COÖRDINATES.—*Continued.*

PLATE 13.					
Star.	X	Y	Star.	X	Y
116	+27.9550	+ 7.5095	130	+35.9797	+21.3352
117	+27.7358	+31.2025	131	+36.5194	+ 0.9401
118	+28.3128	— 2.5863	133	+39.0204	—20.6201
119	+28.8175	+ 8.4039	135	+41.3582	—39.6119
120	+30.0402	+ 3.2120	136	+41.0027	—18.7961
122	+32.3518	— 4.9804	137	+41.5208	+47.1420
123	+32.5684	+23.9455	139	+43.9426	+ 9.1804
124	+33.0706	— 0.3934	140	+43.9188	+13.5272
125	+33.6040	+ 5.8286	142	+47.2345	+38.5260
126	+34.8410	—36.4622	143	+49.8551	+ 4.3730
127	+34.5165	— 9.9205	144	+51.0754	—10.8396
128	+34.4102	+15.5082	145	+50.4086	+21.2446

PLATE 14.					
	X	Y		X	Y
1	—50.2290	+23.3667	40	— 7.0577	+ 2.5950
3	—38.0936	—16.6612	41	— 6.8874	+13.3608
4	—32.9000	+40.2635	42	— 6.7688	— 1.3192
5	—31.7006	+16.9450	43	— 6.6770	+26.4171
6	—29.1190	+39.0065	44	— 6.3460	+ 2.7754
7	—27.8351	+30.2479	45	— 5.8034	—20.2770
9	—23.7203	—29.5144	46	— 5.1233	— 4.7046
10	—22.6506	— 9.6761	47	— 4.8641	—54.0168
11	—21.8377	— 7.9104	48	— 4.6614	—27.8026
12	—21.5916	—20.4489	49	— 4.0601	+ 7.8711
13	—20.9267	— 2.8091	50	— 4.0016	— 2.3588
14	—20.8630	—30.7992	51	— 3.9783	+ 4.7860
15	—20.5265	— 4.8840	52	— 3.9235	— 6.9771
17	—19.8475	—13.7962	53	— 3.7078	— 4.9362
18	—19.2189	—27.3242	54	— 3.0603	— 2.0502
19	—18.1138	—18.5956	56	— 2.2866	— 1.6647
20	—16.3696	+13.2591	57	— 2.0915	— 1.6301
21	—15.1565	— 5.8100	60	— 1.4264	— 2.3086
22	—14.5828	+ 1.9242	61	— 1.1204	— 2.9501
23	—13.6098	—18.4318	62	— 0.6967	— 2.3262
24	—13.2574	+15.8662	63	— 0.5200	— 2.8740
25	—13.2448	—36.0300	64	— 0.5097	— 2.6374
26	—12.8899	— 5.4737	65	— 0.3915	— 9.8199
27	—11.8729	+49.5888	67	0.0000	0.0000
28	—10.7967	+23.5166	69	+ 2.0044	— 6.1504
29	—10.3027	—47.0332	70	+ 2.1053	— 2.0857
30	— 9.3888	+12.7972	71	+ 3.6962	+34.3829
31	— 9.2030	+21.8220	73	+ 3.8026	+22.7074
32	— 8.9651	+44.0284	74	+ 4.0807	— 5.2033
33	— 9.0416	+ 0.0423	76	+ 4.5756	—12.8568
34	— 8.7559	+ 2.5950	77	+ 5.7149	—54.0278
36	— 8.3707	—21.7628	78	+ 6.3458	+10.2203
37	— 8.0263	—19.2706	79	+ 8.0447	—39.1928
38	— 8.0502	—41.0128	80	+ 8.3806	+20.3229
39	— 7.7302	—10.8980	81	+ 9.6007	—29.0726

TABLE III.—CORRECTED COÖRDINATES.—*Continued.*

PLATE 14.					
Star.	X	Y	Star.	X	Y
82	+ 9.5680	— 4.6766	115	+27.0863	— 3.0750
83	+12.3498	+43.5894	116	+27.9683	+ 7.4642
84	+13.2616	—56.9325	117	+27.7916	+31.1591
85	+12.9134	+ 9.8817	118	+28.3114	— 2.6281
86	+14.8370	+19.8173	119	+28.8389	+ 8.3519
87	+15.4965	—16.3424	120	+30.0428	+ 3.1588
88	+17.4831	+ 0.0944	121	+31.2410	— 5.4063
89	+18.1743	—23.7146	122	+32.3416	— 5.0342
90	+18.2882	—20.3835	123	+32.6049	+23.8874
91	+18.4790	—21.1783	124	+33.0717	— 0.4516
92	+18.9489	— 1.3552	125	+33.6134	+ 5.7739
93	+18.9031	+ 9.6054	127	+34.4977	— 9.9706
94	+20.7888	+27.4955	128	+34.4272	+15.4507
95	+21.6166	+ 8.9937	130	+36.0100	+21.2791
97	+23.0292	— 2.5914	131	+36.5211	+ 0.8810
99	+23.8008	+15.1707	132	+37.0470	+24.8582
101	+24.8756	—39.9891	133	+38.9852	—20.6804
102	+24.7328	—17.5750	135	+41.2932	—39.6754
103	+24.7116	+ 5.4172	136	+40.9856	—18.8567
106	+25.8810	—50.6271	137	+41.5969	+47.0767
107	+25.6438	— 1.2301	139	+43.9584	+ 9.1073
108	+25.7094	— 1.7460	140	+43.9348	+13.4560
109	+25.9906	— 1.5406	141	+47.0001	—38.1512
110	+26.6264	— 4.9194	142	+47.2925	+38.4429
111	+27.0639	—43.4490	143	+49.8619	+ 4.2974
112	+26.7402	— 3.4657	145	+50.4416	+21.1631
113	+26.9070	— 2.5948			

PLATE 15.					
1	—50.2370	+23.3406	21	—15.1564	— 5.8221
2	—38.9667	—39.7210	22	—14.5857	+ 1.9152
3	—38.0820	—16.6760	23	—13.6056	—18.4426
4	—32.9187	+40.2420	24	—13.2676	+15.8526
5	—31.7103	+16.9245	25	—13.2271	—36.0325
6	—29.1349	+38.9875	26	—12.8884	— 5.4854
7	—27.8449	+30.2274	27	—11.8915	+49.5810
8	—25.3948	—46.5026	28	—10.8074	+23.5090
9	—23.7082	—29.5247	29	—10.2866	—47.0303
10	—22.6485	— 9.6837	30	— 9.3957	+12.7817
11	—21.8314	— 7.9184	31	— 9.2090	+21.8205
12	—21.5914	—20.4615	32	— 8.9839	+44.0192
13	—20.9272	— 2.8185	33	— 9.0496	+ 0.0354
14	—20.8473	—30.8046	34	— 8.7634	+ 2.5903
15	—20.5328	— 4.8962	35	— 8.4157	+ 4.5327
16	—19.9622	—26.9126	36	— 8.3638	—21.7627
17	—19.8384	—13.8031	37	— 8.0198	—19.2745
18	—19.2080	—27.3346	38	— 8.0362	—41.0138
19	—18.1065	—18.6025	39	— 7.7294	—10.9031
20	—16.3760	+13.2456	40	— 7.0601	+ 2.5888

TABLE III.—CORRECTED COÖRDINATES.—*Continued.*

PLATE 15.					
Star.	X	Y	Star.	X	Y
41	— 6.8973	+13.3490	95	+21.6026	+ 9.0052
42	— 6.7707	— 1.3207	96	+22.6946	+ 9.8460
43	— 6.6937	+26.4136	97	+23.0252	— 2.5787
44	— 6.3545	+ 2.7754	98	+23.6357	—13.4520
45	— 5.8045	—20.2896	99	+23.7866	+15.1837
46	— 5.1250	— 4.7070	100	+24.4324	+ 0.2148
47	— 4.8454	—54.0123	101	+24.8895	—39.9739
48	— 4.6565	—27.8033	102	+24.7355	—17.5616
49	— 4.0683	+ 7.8668	103	+24.7050	+ 5.4317
50	— 3.9999	— 2.3592	104	+24.8519	+11.9951
51	— 3.9840	+ 4.7845	105	+25.3523	—30.7244
52	— 3.9272	— 6.9821	106	+25.8926	—50.6096
53	— 3.7108	— 4.9368	107	+25.6395	+ 1.2141
54	— 3.0700	— 2.0550	108	+25.7032	— 1.7339
55	— 3.0083	— 0.7856	109	+25.9847	— 1.5251
56	— 2.2852	— 1.6696	110	+26.6221	— 4.9160
57	— 2.0961	— 1.6290	111	+27.0740	—43.4343
60	— 1.4346	— 2.3116	112	+26.7349	— 3.4521
61	— 1.1238	— 2.9498	113	+26.8974	— 2.5749
62	— 0.6942	— 2.3297	114	+27.4343	—37.9794
63	— 0.5275	— 2.8726	115	+27.0852	— 3.0653
64	— 0.5088	— 2.6380	116	+27.9588	+ 7.4765
65	— 0.3911	— 9.8152	117	+27.7594	+31.1711
67	0.0000	0.0000	118	+28.3030	— 2.6145
68	+ 0.4892	+ 5.4568	119	+28.8237	+ 8.3694
69	+ 2.0054	— 6.1583	120	+30.0376	+ 3.1741
70	+ 2.1028	— 2.0841	121	+31.2352	— 5.3875
71	+ 3.6768	+34.3847	122	+32.3418	— 5.0170
72	+ 3.7732	+ 6.9254	123	+32.5910	+23.9055
73	+ 3.7943	+22.7028	124	+33.0654	— 0.4357
74	+ 4.0816	— 5.2023	125	+33.6038	+ 5.7915
75	+ 4.6126	—30.7585	126	+34.7847	—36.4946
76	+ 4.5860	—12.8554	127	+34.4971	— 9.9565
77	+ 5.7410	—54.0156	128	+34.4202	+15.4681
78	+ 6.3363	+10.2218	129	+35.4518	— 2.1730
79	+ 8.0519	—39.1820	130	+36.0000	+21.2938
80	+ 8.3659	+20.3157	131	+36.5131	+ 0.8980
81	+ 9.6026	—29.0699	132	+37.0304	+24.8799
82	+ 9.5662	— 4.6761	133	+38.9846	—20.6631
83	+12.3246	+43.5916	134	+39.9369	+ 4.0963
85	+12.9082	+ 9.8922	135	+41.3022	—39.6532
86	+14.8212	+19.8197	136	+40.9794	—18.8370
87	+15.4938	—16.3352	138	+43.4234	+ 5.5227
88	+17.4770	+ 0.1020	139	+43.9406	+ 9.1300
89	+18.1774	—23.7063	140	+43.9251	+13.4805
90	+18.2890	—20.3734	141	+47.0080	—38.1244
91	+18.4854	—21.1682	143	+49.8526	+ 4.3222
92	+18.9394	— 1.3420	144	+51.0491	—10.8868
93	+18.8909	+ 9.6123	145	+50.4244	+21.1872
94	+20.7758	+27.5098			

TABLE III.—CORRECTED COÖRDINATES.—*Continued.*

PLATE 16.					
Star.	X	Y	Star.	X	Y
1	-50.2283	+23.3475	52	-3.9242	-6.9823
2	-38.9728	-39.7206	53	-3.7098	-4.9475
3	-38.0836	-16.6719	54	-3.0668	-2.0556
4	-32.9156	+40.2500	55	-3.0094	-0.7827
5	-31.7097	+16.9264	56	-2.2826	-1.6718
6	-29.1309	+38.9933	57	-2.0956	-1.6337
7	-27.8430	+30.2318	58	-2.0137	-6.4828
8	-25.3960	-46.5016	59	-1.8846	+0.6213
9	-23.7107	-29.5212	60	-1.4339	-2.3116
10	-22.6480	-9.6808	61	-1.1214	-2.9516
11	-21.8313	-7.9174	62	-0.6992	-2.3324
12	-21.5928	-20.4565	63	-0.5256	-2.8757
13	-20.9262	-2.8146	64	-0.5069	-2.6345
14	-20.8538	-30.8048	65	-0.3874	-9.8164
15	-20.5319	-4.8947	66	-0.0096	-2.7531
16	-19.9624	-26.9141	67	0.0000	0.0000
17	-19.8413	-13.8022	68	+0.4998	+5.4567
18	-19.2113	-27.3334	69	+2.0064	-6.1587
19	-18.1078	-18.6028	70	+2.1023	-2.0860
20	-16.3731	+13.2449	71	+3.6839	+34.3843
21	-15.1540	-5.8227	72	+3.7777	+6.9263
22	-14.5816	+1.9170	73	+3.7964	+22.7049
23	-13.6056	-18.4416	74	+4.0808	-5.2042
24	-13.2624	+15.8533	75	+4.6108	-30.7639
25	-13.2310	-36.0328	76	+4.5836	-12.8546
26	-12.8887	-5.4821	77	+5.7388	-54.0174
27	-11.8830	+49.5816	78	+6.3398	+10.2208
28	-10.8063	+23.5122	79	+8.0534	-39.1884
29	-10.2860	-47.0324	80	+8.3648	+20.3170
30	-9.3890	+12.7876	81	+9.5996	-29.0721
31	-9.2039	+21.8204	82	+9.5662	-4.6786
32	-8.9761	+44.0223	85	+12.9149	+9.8870
33	-9.0519	+0.0305	86	+14.8294	+19.8161
34	-8.7597	+2.5912	87	+15.4966	-16.3411
36	-8.3636	-21.7631	88	+17.4767	+0.0982
37	-8.0244	-19.2749	89	+18.1767	-23.7078
38	-8.0425	-41.0148	90	+18.2892	-20.3767
39	-7.7298	-10.8999	91	+18.4852	-21.1698
40	-7.0589	-2.5886	92	+18.9429	-1.3402
41	-6.8896	+13.3503	93	+18.8970	+9.6089
42	-6.7696	+1.3214	94	+20.7789	+27.5048
43	-6.6900	+26.4213	95	+21.6078	+9.0034
44	-6.3499	+2.7738	96	+22.6895	+9.8428
45	-5.7994	-20.2892	97	+23.0242	-2.5845
46	-5.1223	-4.7096	98	+23.6360	-13.4655
47	-4.8511	-54.0161	99	+23.7893	+15.1806
48	-4.6572	-27.8085	100	+24.4364	+0.2106
49	-4.0655	+7.8626	101	+24.8882	-39.9761
50	-3.9988	-2.3606	102	+24.7330	-17.5643
51	-3.9824	+4.7900	103	+24.7091	+5.4264

TABLE III.—CORRECTED COÖRDINATES.—*Continued.*

PLATE 16.					
Star.	X	Y	Star.	X	Y
105	+25.3542	—30.7363	123	+32.5949	+23.9032
106	+25.8934	—50.6182	124	+33.0564	—0.4356
107	+25.6427	—1.2218	125	+33.6065	+5.7870
108	+25.7098	—1.7389	126	+34.7882	—36.5027
109	+25.9852	—1.5320	127	+34.4957	—9.9648
110	+26.6256	—4.9191	128	+34.4190	+15.4594
111	+27.0719	—43.4392	129	+35.4484	—2.1834
112	+26.7401	—3.4567	130	+36.0026	+21.2879
113	+26.9018	—2.5809	131	+36.5149	+0.8913
114	+27.4303	—37.9818	132	+37.0386	+24.8727
115	+27.0846	—3.0674	133	+38.9852	—20.6682
116	+27.9647	+7.4728	134	+39.9367	+4.0932
117	+27.7690	+31.1654	136	+40.9764	—18.8418
118	+28.3060	—2.6186	138	+43.4250	+5.5144
119	+28.8277	+8.3617	139	+43.9444	+9.1235
120	+30.0371	+3.1717	140	+43.9266	+13.4731
121	+31.2374	—5.3916	143	+49.8555	+4.3158
122	+32.3400	—5.0240	145	+50.4267	+21.1812

PLATE 17.					
1	—50.2353	+23.3236	37	—8.0102	—19.2739
3	—38.0738	—16.6924	38	—8.0179	—41.0156
4	—32.9288	+40.2361	39	—7.7218	—10.9014
5	—31.7028	+16.9182	40	—7.0592	+2.5838
6	—29.1456	+38.9800	42	—6.7656	—1.3243
7	—27.8530	+30.2219	43	—6.7008	+26.4183
8	—25.3713	—46.5087	44	—6.3526	+2.7719
9	—23.6942	—29.5288	45	—5.7863	—20.2881
10	—22.6413	—9.6925	46	—5.1222	—4.7121
11	—21.8246	—7.9271	47	—4.8208	—54.0168
12	—21.5810	—20.4636	48	—4.6411	—27.8044
13	—20.9248	—2.8281	49	—4.0656	—7.8662
14	—20.8368	—30.8132	50	—3.9948	—2.3608
18	—19.1952	—27.3388	51	—3.9812	+4.7902
19	—18.0979	—18.6093	52	—3.9209	—6.9817
20	—16.3749	+13.2414	54	—3.0613	—2.0609
21	—15.1489	—5.8261	56	—2.2795	—1.6699
22	—14.5802	+1.9124	57	—2.0949	—1.6353
23	—13.6003	—18.4459	60	—1.4308	—2.3130
25	—13.2111	—36.0353	61	—1.1208	—2.9527
26	—12.8832	—5.4864	62	—0.6914	—2.3308
27	—11.9062	+49.5769	63	—0.5195	—2.8745
28	—10.8111	+23.5061	64	—0.5048	—2.6334
29	—10.2633	—47.0332	65	—0.3866	—9.8195
30	—9.3932	+12.7843	67	0.0000	0.0000
31	—9.2112	+21.8198	69	+2.0131	—6.1593
32	—8.9952	+44.0184	70	+2.1070	—2.0842
33	—9.0406	+0.0402	71	+3.6683	+34.3879
36	—8.3501	—21.7672	72	+3.7726	+6.9202

TABLE III.—CORRECTED COÖRDINATES.—*Continued.*

PLATE 17.					
Star.	<i>X</i>	<i>Y</i>	Star.	<i>X</i>	<i>Y</i>
73	+ 3.7880	+22.7081	111	+27.0968	—43.4274
74	+ 4.0952	— 5.1958	112	+26.7402	— 3.4446
75	+ 4.6261	—30.7577	113	+26.9040	— 2.5686
77	+ 5.7659	—54.0074	115	+27.0857	— 3.0564
78	+ 6.3368	+10.2236	116	+27.9602	+ 7.4846
79	+ 8.0706	—39.1820	117	+27.7516	+31.1810
80	+ 8.3642	+20.3198	118	+28.3076	— 2.6064
82	+ 9.5684	— 4.6710	119	+28.8262	+ 8.3788
83	+12.3138	+43.5961	120	+30.0384	+ 3.1851
85	+12.9118	+ 9.8960	121	+31.2417	— 5.3766
86	+14.8199	+19.8226	122	+32.3423	— 5.0059
87	+15.5052	—16.3313	123	+32.5878	+23.9188
88	+17.4814	+ 0.1078	124	+33.0676	— 0.4260
89	+18.1914	—23.6985	125	+33.6011	+ 5.8013
90	+18.2993	—20.3661	126	+34.8004	—36.4828
91	+18.4974	—21.1613	127	+34.5036	— 9.9460
92	+18.9509	— 1.3333	128	+34.4170	+15.4780
93	+18.8907	+ 9.6121	130	+35.9963	+21.3064
94	+20.7699	+27.5157	131	+36.5181	+ 0.9087
95	+21.6076	+ 9.0140	132	+37.0257	+24.8941
96	+22.6946	+ 9.8546	133	+38.9948	—20.6503
97	+23.0315	— 2.5693	134	+39.9380	+ 4.1111
99	+23.7826	+15.1921	135	+41.3178	—39.6386
100	+24.4386	+ 0.2232	136	+40.9812	—18.8259
102	+24.7429	—17.5511	137	+41.5529	+47.1072
103	+24.7050	+ 5.4383	139	+43.9394	+ 9.1441
106	+25.9109	—50.6006	140	+43.9188	+13.4926
107	+25.6420	— 1.2060	141	+47.0243	—38.1074
108	+25.7090	— 1.7277	142	+47.2576	+38.4890
109	+25.9898	— 1.5154	143	+49.8543	+ 4.3396
110	+26.6289	— 4.9020	145	+50.4107	+21.2065

PLATE 18.					
2	—38.9374	—39.7392	18	—19.1947	—27.3413
3	—38.0681	—16.6932	19	—18.0963	—18.6092
4	—32.9265	+40.2300	20	—16.3780	+13.2412
5	—31.7064	+16.9124	21	—15.1474	— 5.8271
6	—29.1433	+38.9764	22	—14.5824	+ 1.9133
7	—27.8502	+30.2146	23	—13.5982	—18.4458
8	—25.3692	—46.5154	24	—13.2687	+15.8475
9	—23.6917	—29.5316	25	—13.2120	—36.0363
10	—22.6406	— 9.6910	26	—12.8840	— 5.4857
11	—21.8238	— 7.9252	27	—11.9049	+49.5734
12	—21.5790	—20.4676	28	—10.8136	+23.5036
13	—20.9210	— 2.8256	29	—10.2647	—47.0328
14	—20.8315	—30.8123	30	— 9.3970	+12.7848
15	—20.5269	— 4.9049	31	— 9.2132	+21.8185
16	—19.9524	—26.9209	32	— 8.9988	+44.0165
17	—19.8324	—13.8095	33	— 9.0455	+ 0.0374

TABLE III. CORRECTED COÖRDINATES.—*Continued.*

PLATE 18.					
Star.	X	Y	Star.	X	Y
34	— 8.7634	+ 2.5888	84	+ 13.2969	— 56.9113
35	— 8.4114	+ 4.5309	85	+ 12.9036	+ 9.8970
36	— 8.3506	— 21.7646	86	+ 14.8120	+ 19.8264
37	— 8.0102	— 19.2779	87	+ 15.4996	— 16.3271
38	— 8.0140	— 41.0186	88	+ 17.4694	+ 0.1121
39	— 7.7224	— 10.9014	89	+ 18.1848	— 23.6956
40	— 7.0623	+ 2.5863	90	+ 18.2941	— 20.3638
41	— 6.8929	+ 13.3523	91	+ 18.4907	— 21.1576
42	— 6.7690	— 1.3212	92	+ 18.9368	— 1.3288
43	— 6.7020	+ 26.4159	93	+ 18.8844	+ 9.6209
44	— 6.3516	+ 2.7738	94	+ 20.7553	+ 27.5196
45	— 5.7955	— 20.2910	95	+ 21.5948	+ 9.0161
46	— 5.1210	— 4.7082	96	+ 22.6815	+ 9.8552
47	— 4.8190	— 54.0137	97	+ 23.0204	— 2.5668
48	— 4.6423	— 27.8050	98	+ 23.6378	— 13.4439
49	— 4.0714	+ 7.8672	99	+ 23.7730	+ 15.1958
50	— 4.0004	— 2.3617	100	+ 24.4284	+ 0.2232
51	— 3.9860	+ 4.7866	101	+ 24.8986	— 39.9645
52	— 3.9254	— 6.9803	102	+ 24.7364	— 17.5492
53	— 3.7128	— 4.9396	103	+ 24.6943	+ 5.4416
54	— 3.0683	— 2.0552	104	+ 24.8447	+ 12.0085
55	— 3.0143	— 0.7852	106	+ 25.9073	— 50.5980
56	— 2.2838	— 1.6679	107	+ 25.6315	— 1.2023
57	— 2.0910	— 1.6251	108	+ 25.6989	— 1.7204
58	— 2.0126	— 6.4805	109	+ 25.9790	— 1.5135
59	— 1.8844	+ 0.6198	110	+ 26.6158	— 4.9037
60	— 1.4333	— 2.3104	111	+ 27.0844	— 43.4224
61	— 1.1214	— 2.9481	112	+ 26.7314	— 3.4407
62	— 0.6963	— 2.3308	113	+ 26.8929	— 2.5650
63	— 0.5256	— 2.8725	114	+ 27.4467	— 37.9666
64	— 0.5066	— 2.6348	115	+ 27.0814	— 3.0519
65	— 0.3850	— 9.8203	116	+ 27.9503	+ 7.4914
66	— 0.0096	— 2.7530	117	+ 27.7378	+ 31.1865
67	0.0000	0.0000	118	+ 28.2976	— 2.6031
68	+ 0.4871	+ 5.4526	119	+ 28.8127	+ 8.3819
69	+ 2.0104	— 6.1540	120	+ 30.0272	+ 3.1892
70	+ 2.1010	— 2.0809	121	+ 31.2282	— 5.3729
71	+ 3.6640	+ 34.3876	122	+ 32.3332	— 5.0023
72	+ 3.7706	+ 6.9290	123	+ 32.5698	+ 23.9201
73	+ 3.7818	+ 22.7070	124	+ 33.0540	— 0.4200
74	+ 4.0825	— 5.2004	125	+ 33.5932	+ 5.8074
75	+ 4.6224	— 30.7530	126	+ 34.7951	— 36.4787
76	+ 4.5890	— 12.8546	127	+ 34.4908	— 9.9430
77	+ 5.7671	— 54.0142	128	+ 34.4056	+ 15.4834
78	+ 6.3321	+ 10.2275	129	+ 35.4410	— 2.1614
79	+ 8.0705	— 39.1796	130	+ 35.9790	+ 21.3119
80	+ 8.3544	+ 20.3247	131	+ 36.5030	+ 0.9153
81	+ 9.6134	— 29.0644	132	+ 37.0116	+ 24.8934
82	+ 9.5664	— 4.6666	133	+ 38.9872	— 20.6456
83	+ 12.3075	+ 43.5959	134	+ 39.9236	+ 4.1126

TABLE III.—CORRECTED COÖRDINATES.—*Continued.*

PLATE 18.					
Star.	X	Y	Star.	X	Y
135	+41.3061	—39.6340	141	+47.0105	—38.1078
136	+40.9758	—18.8193	143	+49.8360	+ 4.3456
139	+43.9249	+ 9.1485	144	+51.0375	—10.8688
140	+43.9048	+13.4986	145	+50.4006	+21.2068

PLATE 19.					
I	—50.2210	+23.3522	57	— 2.1019	— 1.6342
3	—38.0777	—16.6683	60	— 1.4328	— 2.3134
4	—32.9082	+40.2523	61	— 1.1254	— 2.9501
5	—31.7010	+16.9345	62	— 0.6966	— 2.3309
6	—29.1256	+38.9956	63	— 0.5258	— 2.8739
9	—23.7054	—29.5158	64	— 0.5083	— 2.6352
10	—22.6450	— 9.6785	65	— 0.3967	— 9.8206
11	—21.8278	— 7.9163	67	0.0000	0.0000
12	—21.5910	—20.4554	69	+ 2.0055	— 6.1605
13	—20.9255	— 2.8118	70	+ 2.0982	— 2.0843
14	—20.8482	—30.7996	71	+ 3.6827	+34.3834
17	—19.8390	—13.8013	73	+ 3.7971	+22.7015
18	—19.2085	—27.3291	74	+ 4.0817	— 5.2082
20	—16.3710	+13.2505	76	+ 4.5851	—12.8546
21	—15.1550	— 5.8153	78	+ 6.3386	+10.2200
23	—13.6038	—18.4372	82	+ 9.5632	— 4.6766
25	—13.2303	—36.0283	83	+12.3288	+43.5862
26	—12.8868	— 5.4811	85	+12.9093	+ 9.8880
27	—11.8776	+49.5823	86	+14.8229	+19.8209
28	—10.8005	+23.5114	87	+15.4912	—16.3374
29	—10.2872	—47.0298	88	+17.4714	+ 0.0981
30	— 9.3932	+12.7891	89	+18.1721	—23.7080
31	— 9.2012	+21.8242	90	+18.2826	—20.3785
32	— 8.9757	+44.0198	91	+18.4792	—21.1715
33	— 9.0460	+ 0.0392	92	+18.9388	— 1.3484
36	— 8.3630	—21.7626	95	+21.6009	+ 9.0008
37	— 8.0208	—19.2742	97	+23.0219	— 2.5840
38	— 8.0358	—41.0178	99	+23.7842	+15.1790
39	— 7.7291	—10.8990	100	+24.4276	+ 0.2085
40	— 7.0595	+ 2.5903	102	+24.7261	—17.5666
42	— 6.7704	— 1.3200	103	+24.7001	+ 5.4255
43	— 6.6876	+26.4145	107	+25.6354	— 1.2220
44	— 6.3522	+ 2.7772	108	+25.7003	— 1.7412
46	— 5.1258	— 4.7065	109	+25.9813	— 1.5323
47	— 4.8486	—54.0162	110	+26.6197	— 4.9210
48	— 4.6576	—27.8034	112	+26.7310	— 3.4604
49	— 4.0667	+ 7.8682	113	+26.8948	— 2.5822
50	— 3.9992	— 2.3592	115	+27.0794	— 3.0724
51	— 3.9800	+ 4.7847	116	+27.9563	+ 7.4700
52	— 3.9285	— 6.9794	118	+28.3001	— 2.6245
53	— 3.7055	— 4.9370	120	+30.0333	+ 3.1673
54	— 3.0658	— 2.0573	121	+31.2288	— 5.3958
56	— 2.2803	— 1.6696	122	+32.3340	— 5.0246

TABLE III.—CORRECTED COÖRDINATES.—*Continued.*

PLATE 19.					
Star.	X	Y	Star.	X	Y
123	+32.5872	+23.1903	131	+36.5044	+ 0.8885
124	+33.0662	— 0.4455	133	+38.9774	—20.6740
125	+33.5980	+ 5.7816	135	+41.2853	—39.6611
127	+34.4880	— 9.9719	136	+40.9667	—18.8507
128	+34.4165	+15.4576	140	+43.9207	+13.4670
130	+35.9943	+21.2858	143	+49.8452	+ 4.3066

PLATE 20.					
I					
1	—50.2222	+23.3554	42	— 6.7702	— 1.3184
2	—38.9697	—39.7155	43	— 6.6896	+26.4229
3	—38.0788	—16.6671	44	— 6.3516	+ 2.7780
4	—32.9076	+40.2524	45	— 5.8050	—20.2876
5	—31.7005	+16.9343	46	— 5.1280	— 4.7038
6	—29.1260	+38.9968	47	— 4.8567	—54.0106
7	—27.8390	+30.2349	48	— 4.6576	—27.8024
8	—25.3980	—46.4959	49	— 4.0659	+ 7.8669
9	—23.7080	—29.5146	50	— 3.9996	— 2.3579
10	—22.6466	— 9.6767	51	— 3.9839	+ 4.7880
11	—21.8269	— 7.9100	52	— 3.9310	— 6.9786
12	—21.5918	—20.4517	53	— 3.7131	— 4.9396
13	—20.9261	— 2.1899	54	— 3.0671	— 2.0533
14	—20.8510	—30.8002	55	— 3.0104	— 0.7831
15	—20.5299	— 4.8869	56	— 2.2836	— 1.6695
16	—19.9632	—26.9085	57	— 2.0980	— 1.6293
17	—19.8383	—13.7959	59	— 1.8932	+ 0.6206
18	—19.2104	—27.3275	60	— 1.4310	— 2.3113
19	—18.1108	—18.5947	61	— 1.1212	— 2.9502
20	—16.3706	+13.2514	62	— 0.6975	— 2.3299
21	—15.1548	— 5.8174	63	— 0.5267	— 2.8726
22	—14.5820	+ 1.9205	64	— 0.5094	— 2.6334
23	—13.6076	—18.4371	65	— 0.3929	— 9.8208
24	—13.2608	+15.8563	66	— 0.0076	— 2.7558
25	—13.2301	—36.0292	67	0.0000	0.0000
26	—12.8874	— 5.4779	68	+ 0.4876	+ 5.4588
27	—11.8774	+49.5823	69	+ 2.0056	— 6.1570
28	—10.8009	+23.5114	70	+ 2.1028	— 2.0838
29	—10.2896	—47.0288	71	+ 3.6863	+34.3830
30	— 9.3893	+12.7876	72	+ 3.7756	+ 6.9236
31	— 9.2052	+21.8230	73	+ 3.7991	+22.7045
32	— 8.9744	+44.0245	74	+ 4.0818	— 5.2063
33	— 9.0427	+ 0.0380	75	+ 4.6040	—30.7632
34	— 8.7604	+ 2.5926	76	+ 4.5860	—12.8568
35	— 8.4068	+ 4.5326	77	+ 5.7322	—54.0174
36	— 8.3647	—21.7607	78	+ 6.3387	+10.2210
37	— 8.0208	—19.2698	79	+ 8.0464	—39.1874
38	— 8.0353	—41.0140	81	+ 9.5954	—29.0718
39	— 7.7292	—10.8952	82	+ 9.5608	— 4.6754
40	— 7.0617	+ 2.5903	83	+12.3356	+43.5883
41	— 6.8903	+13.3498	85	+12.9112	+ 9.8880

TABLE III.—CORRECTED COÖRDINATES.—*Continued.*

PLATE 20.					
Star.	X	Y	Star.	X	Y
86	+14.8272	+19.8160	114	+27.4236	-37.9906
87	+15.4918	-16.3380	115	+27.0806	-3.0741
88	+17.4744	+0.0968	116	+27.9584	+7.4696
89	+18.1736	-23.7097	118	+28.3020	-2.6238
90	+18.2817	-20.3816	119	+28.8248	+8.3580
91	+18.4771	-21.1726	120	+30.0350	+3.1693
92	+18.9373	-1.3454	121	+31.2320	-5.3958
93	+18.8930	+9.6031	122	+32.3382	-5.0257
94	+20.7747	+27.5051	123	+32.5898	+23.8970
95	+21.6016	+9.0030	124	+33.0615	-0.4416
96	+22.7003	+9.8435	125	+33.6032	+5.7819
97	+23.0231	-2.5844	126	+34.7805	-36.5028
99	+23.7863	+15.1782	127	+34.4890	-9.9682
100	+24.4311	+0.2086	128	+34.4188	+15.4592
101	+24.8790	-39.9829	129	+35.4501	-2.1812
102	+24.7309	-17.5651	130	+36.0000	+21.2868
103	+24.7045	+5.4247	131	+36.5094	+0.8881
104	+24.8591	+11.9861	133	+38.9790	-20.6734
106	+25.8815	-50.6184	134	+39.9354	+4.0831
107	+25.6363	-1.2213	135	+41.2929	-39.6676
108	+25.7014	-1.7413	136	+40.9705	-18.8473
109	+25.9858	-1.5353	139	+43.9458	+9.1166
110	+26.6206	-4.9218	140	+43.9228	+13.4677
111	+27.0668	-43.4426	143	+49.8466	+4.3086
112	+26.7326	-3.4598	144	+51.0432	-10.9043
113	+26.8962	-2.5842	145	+50.4180	+21.1703

PLATE 21.					
	X	Y		X	Y
1	-50.2276	+23.3485	25	-13.2296	-36.0352
3	-38.0784	-16.6728	26	-12.8855	-5.4813
4	-32.9135	+40.2510	27	-11.8864	+49.5824
5	-31.7044	+16.9316	28	-10.8636	+23.5112
6	-29.1314	+38.9940	29	-10.2860	-47.0370
7	-27.8405	+30.2338	30	-9.3896	+12.7891
9	-23.7078	-29.5199	31	-9.2044	+21.8248
10	-22.6481	-9.6821	32	-8.9787	+44.0270
11	-21.8331	-7.9202	33	-9.0423	+0.0377
12	-21.5860	-20.4600	36	-8.3627	-21.7630
13	-20.9252	-2.8158	37	-8.0151	-19.2745
14	-20.8481	-30.8057	38	-8.0295	-41.0171
15	-20.5282	-4.8866	39	-7.7276	-10.9005
17	-19.8352	-13.8046	40	-7.0610	+2.5914
18	-19.2071	-27.3342	42	-6.7693	-1.3198
19	-18.1027	-18.6012	43	-6.6884	+26.4194
20	-16.3738	+13.2507	44	-6.3519	+2.7772
21	-15.1526	+5.8184	45	-5.8040	-20.2864
22	-14.5820	+1.9187	46	-5.1223	-4.7075
23	-13.6025	-18.4418	47	-4.8418	-54.0169
24	-13.2624	+15.8566	48	-4.6493	-27.8050

TABLE III.—CORRECTED COÖRDINATES.—*Continued.*

PLATE 21.					
Star.	X	Y	Star.	X	Y
49	— 4.0654	+ 7.8688	93	+ 18.9025	+ 9.6072
50	— 3.9962	— 2.3593	94	+ 20.7809	+ 27.5125
51	— 3.9785	+ 4.7876	95	+ 21.6089	+ 9.0046
52	— 3.9256	— 6.9796	97	+ 23.0273	— 2.5798
53	— 3.7092	— 4.9386	99	+ 23.7882	+ 15.1849
54	— 3.0616	— 2.0528	100	+ 24.4346	+ 0.2018
56	— 2.2821	— 1.6673	102	+ 24.7384	— 17.5647
57	— 2.0924	— 1.6266	103	+ 24.7079	+ 5.4279
60	— 1.4309	— 2.3079	106	+ 25.8952	— 50.6132
61	— 1.1236	— 2.9483	107	+ 25.6413	— 1.2200
62	— 0.6973	— 2.3294	108	+ 25.7120	— 1.7380
63	— 0.5215	— 2.8721	109	+ 25.8892	— 1.5337
64	— 0.5037	— 2.6350	110	+ 26.6264	— 4.9204
65	— 0.3855	— 9.8244	111	+ 27.0778	— 43.4452
67	0.0000	0.0000	112	+ 26.7389	— 3.4548
69	+ 2.0090	— 6.1548	113	+ 26.9033	— 2.5810
70	+ 2.1040	— 2.0813	115	+ 27.0895	— 3.0689
71	+ 3.6816	+ 34.3884	116	+ 27.9626	+ 7.4740
72	+ 3.7794	+ 6.9261	117	+ 27.7636	+ 31.1668
73	+ 3.7956	+ 22.7072	118	+ 28.3100	— 2.6197
74	+ 4.0850	— 5.2026	119	+ 28.8318	+ 8.3662
75	+ 4.6175	— 30.7639	120	+ 30.0405	+ 3.1709
76	+ 4.5929	— 12.8580	121	+ 31.2368	— 5.3910
77	+ 5.7480	— 54.0218	122	+ 32.3456	— 5.0224
78	+ 6.3416	+ 10.2238	123	+ 32.5945	+ 23.9037
79	+ 8.0600	— 39.1898	124	+ 33.0708	— 0.4381
80	+ 8.3713	+ 20.3232	125	+ 33.6038	+ 5.7865
81	+ 9.6076	— 29.0752	126	+ 34.7860	— 36.5008
82	+ 9.5712	— 4.6758	127	+ 34.5022	— 9.9636
83	+ 12.3312	+ 43.5938	128	+ 34.4238	+ 15.4642
84	+ 13.2788	— 56.9241	129	+ 35.4480	— 2.1755
85	+ 12.9161	+ 9.8910	130	+ 36.0012	+ 21.2923
86	+ 14.8295	+ 19.8192	131	+ 36.5151	+ 0.8951
87	+ 15.4993	— 16.3371	132	+ 37.0395	+ 24.8702
88	+ 17.4818	+ 0.1014	133	+ 38.9903	— 20.6698
89	+ 18.1824	— 23.7078	136	+ 40.9834	— 18.8442
90	+ 18.2923	— 20.3783	140	+ 43.9301	+ 13.4716
91	+ 18.4904	— 21.1707	143	+ 49.8553	+ 4.3177
92	+ 18.9450	— 1.3439	145	+ 50.4271	+ 21.1748

PLATE 22.					
I	X	Y	II	X	Y
1	— 50.2333	+ 23.3408	11	— 21.8280	— 7.9200
3	— 38.0805	— 16.6815	12	— 21.5864	— 20.4624
4	— 32.9256	+ 40.2470	13	— 20.9256	— 2.8210
5	— 31.7110	+ 16.9276	14	— 20.8433	— 30.8137
6	— 29.1354	+ 38.9942	15	— 20.5281	— 4.8963
8	— 25.3784	— 46.5107	17	— 19.8305	— 13.8118
9	— 23.7031	— 29.5278	18	— 19.2040	— 27.3384
10	— 22.6473	— 9.6867	19	— 18.1038	— 18.6048

TABLE III.—CORRECTED COÖRDINATES.—*Continued.*

PLATE 22.					
Star.	X	Y	Star.	X	Y
20	—16.3757	+13.2502	71	+ 3.6799	+34.3870
21	—15.1517	— 5.8216	73	+ 3.7953	+22.7118
22	—14.5832	+ 1.9146	74	+ 4.0931	— 5.2041
23	—13.6060	—18.4460	78	+ 6.3398	+10.2234
24	—13.2581	+15.8486	82	+ 9.5716	— 4.6744
25	—13.2173	—36.0372	83	+12.3218	+43.5965
26	—12.8869	— 5.4844	85	+12.9133	+ 9.8900
27	—11.8942	+49.5861	86	+14.8230	+19.8232
28	—10.8085	+23.5130	87	+15.5029	—16.3349
29	—10.2744	—47.0375	88	+17.4856	+ 0.1003
30	— 9.3852	+12.7818	89	+18.1862	+23.7055
31	— 9.2073	+21.8277	90	+18.2961	—20.3760
32	— 8.9882	+44.0284	91	+18.4907	—21.1697
33	— 9.0398	+ 0.0355	92	+18.9424	— 1.3404
36	— 8.3507	—21.7640	97	+23.0359	— 2.5773
37	— 8.0142	—19.2779	99	+23.7872	+15.1859
38	— 8.0221	—41.0240	100	+24.4336	+ 0.2152
39	— 7.7226	—10.9018	102	+24.7420	—17.5625
40	— 7.0578	+ 2.5905	103	+24.7082	+ 5.4310
42	— 6.7641	— 1.3236	107	+25.6440	— 1.2151
43	— 6.6937	+26.4216	108	+25.7166	— 1.7387
44	— 6.3496	+ 2.7777	110	+26.6306	— 4.9218
46	— 5.1227	— 4.7090	111	+27.0884	—43.4342
47	— 4.8331	—54.0234	112	+26.7442	— 3.4522
48	— 4.6456	—27.8076	113	+26.9082	— 2.5768
49	— 4.0635	+ 7.8710	115	+27.0959	— 3.0656
50	— 3.9946	— 2.3602	116	+27.9648	+ 7.4779
51	— 3.9717	+ 4.7910	118	+28.3154	— 2.6131
52	— 3.9221	— 6.9824	119	+28.8340	+ 8.3648
53	— 3.7040	— 4.9412	120	+30.0425	+ 3.1775
54	— 3.0572	— 2.0538	122	+32.3466	— 5.0154
56	— 2.2778	— 1.6780	123	+32.5937	+23.9100
57	— 2.0962	— 1.6366	125	+33.6083	+ 5.7910
60	— 1.4299	— 2.3116	127	+34.5068	— 9.9600
61	— 1.1204	— 2.9556	128	+34.4245	+15.4698
62	— 0.6943	— 2.3362	130	+35.9991	+21.2936
63	— 0.5230	— 2.8743	131	+36.5149	+ 0.9000
64	— 0.5052	— 2.6348	133	+38.9947	—20.6642
65	— 0.3796	— 9.8292	136	+40.9804	—18.8368
67	0.0000	0.0000	140	+43.9271	+13.4809
69	+ 2.0108	— 6.1536	143	+49.8590	+ 4.3195
70	+ 2.1063	— 2.0846			

PLATE 23.

1	—50.2482	+23.3346	8	—25.3800	—46.5161
3	—38.0840	—16.6925	9	—23.7008	—29.5315
4	—32.9407	+40.2394	10	—22.6518	— 9.6890
5	—31.7202	+16.9209	11	—21.8304	— 7.9240
6	—29.1550	+38.9868	12	—21.5858	—20.4710

TABLE III.—CORRECTED COÖRDINATES.—*Concluded.*

PLATE 23.					
Star.	X	Y	Star.	X	Y
13	-20.9334	-2.8213	74	+4.0878	-5.2025
14	-20.8397	-30.8170	75	+4.6230	-30.7646
15	-20.5348	-4.9015	78	+6.3338	+10.2267
17	-19.8406	-13.8122	79	+8.0677	-39.1849
18	-19.2030	-27.3416	82	+9.5708	-4.6694
19	-18.1054	-18.6091	83	+12.3112	+43.6051
20	-16.3858	+13.2446	84	+13.2986	-56.9187
21	-15.1564	-5.8249	85	+12.9081	+9.8981
22	-14.5928	+1.9118	86	+14.8178	+19.8280
23	-13.6053	-18.4455	87	+15.5064	-16.3322
24	-13.2666	+15.8501	88	+17.4773	+0.1084
25	-13.2160	-36.0373	89	+18.1934	-23.7030
26	-12.8936	-5.4844	90	+18.2996	-20.3692
27	-11.9100	+49.5817	91	+18.4951	-21.1656
28	-10.8185	+23.5083	92	+18.9407	-1.3318
29	-10.2708	-47.0378	94	+20.7718	+27.5205
30	-9.4024	+12.7836	95	+21.5995	+9.0216
31	-9.2206	+21.8220	97	+23.0293	-2.5690
32	-8.9996	+44.0248	99	+23.7856	+15.1973
33	-9.0518	+0.0374	101	+24.9060	-39.9790
36	-8.3564	-21.7669	102	+24.7453	-17.5550
37	-8.0252	-19.2796	103	+24.7079	+5.4409
38	-8.0183	-41.0230	107	+25.6410	-1.2085
39	-7.7275	-10.9028	108	+25.7039	-1.7242
40	-7.0660	+2.5882	109	+25.9835	-1.5220
42	-6.7706	-1.3213	110	+26.6278	-4.9072
43	-6.7078	+26.4235	111	+27.0895	-43.4264
44	-6.3610	+2.7735	112	+26.7395	-3.4451
46	-5.1256	-4.7062	113	+26.9038	-2.5686
47	-4.8254	-54.0175	115	+27.0910	-3.0596
48	-4.6480	-27.8072	116	+27.9590	+7.4870
49	-4.0728	+7.8676	118	+28.3092	-2.6077
50	-4.0057	-2.3636	119	+28.8312	+8.3782
51	-3.9825	+4.7870	120	+30.0377	+3.1878
52	-3.9260	-6.9806	121	+31.2427	-5.3766
53	-3.7075	-4.9413	122	+32.3463	+5.0076
54	-3.0680	-2.0572	123	+32.5839	+23.9192
56	-2.2817	-1.6717	25	+33.6080	+5.7993
57	-2.0980	-1.6300	126	+34.8151	-36.4892
60	-1.4319	-2.3122	127	+34.5040	-9.9488
61	-1.1243	-2.9481	128	+34.4247	+15.4816
62	-0.6955	-2.3311	130	+35.9972	+21.3079
63	-0.5280	-2.8732	131	+36.5174	+0.9106
64	-0.5079	-2.6346	133	+39.0028	-20.6543
65	-0.3811	-9.8214	134	+39.9438	+4.1103
66	-0.0210	-2.7530	135	+41.3206	-39.6466
67	0.0000	0.0000	136	+40.9930	-18.8308
69	+2.0095	-6.1568	140	+43.9321	+13.4948
70	+2.1017	-2.0842	141	+47.0401	-38.1135
71	+3.6663	+34.3912	143	+49.8647	+4.3395
73	+3.7898	+22.7116	145	+50.4214	+21.2004

IV. METHOD OF REDUCTION.

Let us define as "standard" the coördinates of a star freed from all atmospheric effects and measured from the true center of the plate, the y -axis lying exactly in the plane of a declination circle. Measured coördinates become standard when they are freed from the effects of refraction, precession, nutation, aberration, and of certain errors in the adjustment of the plate.

Before making these corrections it is convenient to change the unit from the millimeter to the second of arc, using an approximate scale-value, which in this case is 1 mm. = $52''.90$. A small correction to this scale-value will be determined as one of the constants for each plate.

Refraction. — Refraction affects both position angles and distances of stars upon the photographic plate. Various formulas have been developed for the determination of its effect upon the x - and y -coördinates. We have used those of Jacoby,¹ first deduced by him from formulas published by Rambaut in the *Astronomische Nachrichten*, No. 3125. The same formulas may be derived directly from Bessel's general formulas.²

Let

φ = the latitude of the place ;

θ = the sidereal time of exposure as given in Table I ;

α and δ = the right ascension and declination of the central star ;

β = the usual refraction constant multiplied by the factor $\frac{8}{8} \frac{8}{8}$ because of the increased refrangibility of photographic rays.³

¹ *Astron. Jour.*, No. 387.

² See The Præsepe Group, by F. Schlesinger. *Contrib. Col. Univ. Obs.*, No. 15, p. 285.

³ See Rambaut, Additional note on the corrections for refraction to measures of stellar photographs ; Scheiner, Zusatz zu Herrn Rambauts Note über Refraction bei Sternphotographien. *Astron. Nach.*, No. 3255.

Compute :

$$\begin{aligned}\tan N &= \cot \phi \cos (\theta - a'), \\ G &= \cot (\delta + N), \\ H &= \tan (\theta - a) \sin N \operatorname{cosec} (\delta + N), \\ M_x &= \beta (1 + H^2) \sin i'', \\ N_x &= \beta (GH - H \tan \delta) \sin i'', \\ M_y &= \beta (GH + H \tan \delta) \sin i'', \\ N_y &= \beta (1 + G^2) \sin i''.\end{aligned}$$

Then, if we denote the measured coördinates by X' and Y' , the same coördinates corrected for refraction by X and Y , we have the following equations :

$$\begin{aligned}X &= X' + M_x X' + N_x Y', \\ Y &= Y' + M_y Y' + N_y X' .\end{aligned}$$

As given here these formulas do not include terms of the second and higher orders, but these are all less than $0''.01$ for plates used in the final catalogue. Second order terms were computed for Plate 9, which has the greatest zenith distance, but in no case did their sum exceed $0''.03$. Refraction formulas complete to terms of the fourth order are given by Zurhellen in his "Himmelsaufnahmen."¹

The refraction coefficients for the different plates are given in the subjoined table.

TABLE IV.—REFRACTION COEFFICIENTS.

Plate.	M_x	N_x	M_y	N_y
12	+0.000317	+0.000138	-0.000098	+0.000315
13	+ .000320	+ .000157	- .000113	+ .000310
14	+ .000331	+ .000156	- .000113	+ .000323
15	+ .000331	- .000161	+ .000116	+ .000321
16	+ .000360	- .000226	+ .000173	+ .000315
17	+ .000404	- .000289	+ .000240	+ .000309
18	+ .000573	+ .000394	- .000474	+ .000302
19	+ .000488	+ .000361	- .000363	+ .000296
20	+ .000419	+ .000308	- .000270	+ .000299
21	+ .000404	+ .000296	- .000256	+ .000294
22	+ .000371	+ .000261	- .000213	+ .000292
23	+ .000317	+ .000166	- .000121	+ .000301

¹ Darlegung und Kritik der zur Reduktion photographischer Himmelsaufnahmen aufgestellten Formeln und Methoden. W. Zurhellen, Bonn, 1904.

Precession and Nutation.—Precession and nutation merely rotate the axes of reference, not affecting in any way the positions of the stars relative to each other. It is unnecessary to make any correction for this rotation, for if in the determination of our plate constants we use star-places referred to the mean equinox of the epoch of our final catalogue, the orientation determined will give the direction of the axes for that epoch.

Aberration.—No correction was applied for aberration. Bessel¹ has shown that its effect is to alter the distances between the stars by a constant factor and to change the position angles equally in all directions. The first effect can, therefore, be included in the correction to the scale-value, the second in the orientation constant.

The Plate Constants.—The exact scale-value, position of the origin of measures, and direction of axes of reference must be determined for each plate from the positions of known stars. We assume that we know for each plate the right ascension and declination of the central star and also of certain stars found upon the plate and distributed with some uniformity over its surface. From these data we determine (*a*) standard coördinates for these known stars, and (*b*) the constants for each plate.

We have used Jacoby's series² for the transformation of differences of right ascension and declination into standard coördinates. We give them below to terms of the third order inclusive. Fourth order terms were entirely negligible.

Let

α and δ = the right ascension and declination of the central star ;

α' and δ' = the right ascension and declination of any other star upon the plate ;

$$x' = (\alpha' - \alpha) \cos \delta,$$

$$y' = \delta' - \delta ;$$

x and y = the standard coördinates sought.

¹ *Astronomische Untersuchungen*, Vol. I, p. 207.

² *Vierteljahrsschrift der Astronomischen Gesellschaft*, 1895, p. 114. Cf. also *Contrib. Col. Univ. Obs.*, No. 23, p. 6.

Then

$$\begin{aligned}
 x &= x' + x'y' [-\tan \delta] \sin 1'' \\
 &\quad + x'^3 [\tfrac{1}{3}(1 - \tfrac{1}{2} \tan^2 \delta)] \sin^2 1'' \\
 y &= y' + x'^2 [\tfrac{1}{2} \tan \delta] \sin 1'' \\
 &\quad + x'^2 y' [\tfrac{1}{2}(1 - \tan^2 \delta)] \sin 1'' \\
 &\quad + \tfrac{1}{3} y'^3 \sin^2 1''.
 \end{aligned}$$

The next step is to determine the following plate constants:

p = a correction to the assumed scale-value such that the true value will be $52''.90 (1 + p)$.

r = a small angle through which the axes of reference must be rotated in order to bring the y -axis into coincidence with a projected declination circle. This correction is positive in the direction of decreasing position angle.

k = a correction to the assumed center, measured in the direction of decreasing right ascensions and expressed in seconds of arc of a great circle.

c = a corresponding correction in declination.

The corrections required by the two coördinates are:

$$\text{For } X, \quad pX + rY + k,$$

$$\text{For } Y, \quad pY - rX + c.$$

If, as before, X and Y represent the measured coördinates freed from the effects of refraction, we have the equations

$$pX + rY + k = x - X,$$

$$pY - rX + c = y - Y.$$

If the measured coördinates were entirely free from accidental errors, these equations would be rigorously true and any pair of known stars would serve for the determination of the four plate constants. Because of these accidental errors the constants so determined vary somewhat with the pair of stars selected, and the most accurate values will result only from a least squares solution of a large number of equations.

Owing to the peculiar arrangement of the coefficients of p and r , a rigorous solution of these equations is easily made as follows:¹

Let us suppose there are n known stars in the solution and that the square brackets have their usual significance.

Let

$$\begin{aligned} A &= [XX] - \frac{[X]^2}{n}, \\ C &= [X(X-x)] - \frac{[X][X-x]}{n}, \\ D &= [YY] - \frac{[Y]^2}{n}, \\ E &= [Y(X-x)] - \frac{[Y][X-x]}{n}, \\ C' &= [Y(Y-y)] - \frac{[Y][Y-y]}{n}, \\ E' &= -[X(Y-y)] + \frac{[X][Y-y]}{n}. \end{aligned}$$

Then

$$p = -\frac{C + C'}{A + D}, \text{ weight of } p = A + D,$$

$$r = -\frac{E + E'}{A + D}, \text{ weight of } r = A + D,$$

$$k = -\frac{1}{n} \{ [X]p + [Y]r + [X-x] \}, \text{ weight of } k = n - \frac{[X]^2 + [Y]^2}{[XX] + [YY]},$$

$$c = -\frac{1}{n} \{ [Y]p - [X]r + [Y-y] \}, \text{ weight of } c = n - \frac{[X]^2 + [Y]^2}{[XX] + [YY]}.$$

If v_1, v_2 , etc., represent the residuals for these equations, the probable error of a single equation will be

$$\pm 0.6745 \sqrt{\frac{[vv]}{2n-4}}.$$

¹ H. Jacoby. Note on the Solution by Least Squares of the Equations arising in the Reduction of Photographic Star-plates. *Mo. Not. R. A. S.*, May, 1896, p. 424.

V. INTER-COMPARISON OF THE PLATES.

We have explained the corrections necessary to reduce the measured coördinates of a given plate to the corresponding standard coördinates of an ideal plate. It is evident that the equations given may also be used for the reduction of the coördinates of one plate to those of any other having approximately the same center. Jacoby has shown¹ that when X and Y do not exceed 1° in arc of a great circle, a linear relation exists between the coördinates of any two plates the distance between whose centers does not exceed $33''$; *i. e.*, under these conditions terms of the second order are less than $0''.01$.

We have taken advantage of this relation in our reduction of the Perseus plates. Eighty-two stars found upon each of eleven plates were selected as standards and a "mean" plate was formed, the coördinates of each star upon this imaginary plate being the average X and Y for that star. The mean date of these eleven plates was 1874.37. Using these values in place of the standard x and y of the equations on page 32, a least squares solution was made for each of these plates and the constants determined whereby it could be reduced to the mean plate. The constants for those plates which lack some of the eighty-two standard stars were determined from such of these stars as were found upon the plate considered. The large number of standard stars makes possible a very accurate determination of constants.

¹ On the Reduction of Stellar Photographs. *Contrib. Col. Univ. Obs.*, No. 10, p. 115.

Table V gives the values of p , r , k and c for each plate, and also the probable error of a single equation.

TABLE V.—PLATE CONSTANTS.

Plate.	p	r	Probable Error of p or r .	k	c	Probable Error of k or c .	Probable Error of One Equation.
7	-0.000297	+0.002227	± 0.000019	-.125	-.120	± 0.026	± 0.1486
8	-.000131	+.002562	.000014	-.077	-.127	.019	.1258
9	-.000287	+.003465	.000018	-.044	-.067	.027	.1861
10	-.000166	+.002084	.000017	+.025	-.118	.025	.1893
11	-.000199	+.002622	.000015	-.054	+.006	.022	.1572
12	-.000060	+.001037	.000006	+.181	+.005	.009	.0811
13	-.000061	+.000844	.000005	-.049	-.061	.008	.0720
14	-.000020	-.000716	.000007	-.087	+.010	.011	.0942
15	+.000065	+.000005	.000006	+.108	+.027	.008	.0751
16	+.000031	-.000065	.000005	+.003	+.067	.007	.0626
17	-.000010	+.000453	.000005	-.128	+.004	.008	.0695
18	+.000089	-.000156	.000003	+.081	-.047	.005	.0449
19	+.000087	-.000698	.000005	+.058	+.060	.007	.0661
20	+.000096	-.000636	.000004	+.044	-.005	.006	.0527
21	-.000009	-.000494	.000004	-.105	+.007	.006	.0556
22	-.000042	-.000300	.000006	-.155	+.036	.010	.0869
23	-.000081	+.000044	.000006	+.102	-.039	.008	.0760

It is now possible to decide whether different weights should be assigned to the individual plates. The probable errors of Plates 12-23 do not differ widely and the plates were considered equally good when measured. These plates were therefore given equal weight. Plates 7-11 contained less than one half the stars of our catalogue and were noted as inferior to the others at the time of measurement. Since the measures were at hand, however, it was thought best to compare the resulting values of X and Y with those of the mean plate and determine the probable error of a single equation. These are included in Table V, and it will be noted that they are about twice as large as the probable errors of the later plates of the series.

The values given there for the probable errors of plates used in the formation of the mean plate, should be multiplied by the factor 1.1 before comparison with those of other plates. This factor is obtained as follows :

Let

X_1, X_2 , etc., be the values of the coördinates upon plates 1, 2, etc. ;

X_m be the mean coördinate, or

$$\frac{X_1 + X_2 + \dots + X_{11}}{11};$$

r_1, r_2 , etc., be the probable errors of Plates 1, 2, etc. ;

r'_1, r'_2 , etc., be the corresponding errors freed from their effect upon the mean, and assume these errors to be of the same magnitude.

Then

$$X_1 - X_m = \frac{1}{11}X_1 - \frac{1}{11}X_2 - \frac{1}{11}X_3 - \dots - \frac{1}{11}X_{11},$$

and

$$r_1^2 = (\frac{1}{11})^2 r_1'^2 + (\frac{1}{11})^2 r_2'^2 + \dots + (\frac{1}{11})^2 r_{11}'^2.$$

Solving and omitting subscripts,

$$r' = 1.1 r.$$

The mean value of the probable errors given in Table V for Plates 12-18, 20-23, is $\pm 0''.0701$. Multiplied by the factor 1.1, this becomes $\pm 0''.0771$. The corresponding mean for Plates 7-11 is $\pm 0''.1614$. This difference is too large to be accounted for by proper motion during the interval between 1870.23, the epoch of these plates, and 1874.37, the mean epoch of the other plates. To find what average proper motion would account for the discrepancy, a value for μ was determined to satisfy the equation

$$\sqrt{(0''.077)^2 + \mu^2} = 0''.161,$$

and found to be $\pm 0''.141$. This would mean an average annual proper motion of $\pm 0''.035$ in arc of a great circle. The small residuals obtained later from a comparison of the photographic places of eleven standard stars with Schur's heliometer results, when there was an interval of nineteen years between the photographs and the heliometer measures, would indicate that these star-places, at least, were not affected by proper motion of any such magnitude.

A comparison was also made of the residuals for individual stars as found upon the various plates to see if there could be any possible systematic displacement of the images. No evidence for such displacement was found.

It was concluded, therefore, that the large probable error of these plates was due to the character of the star-images, and the results of these measures were not included in the final catalogue.

Plate 19 was not used in the formation of the mean plate because of a defect in the image of one of the stars which we wished to use as a standard in the determination of right ascension and declination. In general, however, the plate is as good as the others, and has been given equal weight with them in the determination of the mean X 's and Y 's of Table VI.

All stars not included in the list of standards were reduced to the mean plate by means of the plate constants of Table V. When refraction corrections had not been applied previously, their coefficients were united with the constants so as to give total corrections for X' and Y' respectively.

These are :

$$\text{For } X', \quad (\phi + M_x)X' + (r + N_x)Y' + k,$$

$$\text{For } Y', \quad (-r + M_y)X' + (\phi + N_y)Y' + c.$$

Means of the coördinates obtained in this way were adopted as the values of X_m and Y_m for stars not found on all plates.

These mean coördinates are given for all stars in Table VI, together with the residuals for each plate. The coördinate of a star upon any one plate is equal to the algebraic sum of the mean coördinate and the residual for that plate.

The probable error of a mean coördinate for a star found upon n plates may be expressed by the equation

$$r_0 = \frac{\sqrt{r_1'^2 + r_2'^2 + \dots + r_n'^2}}{n},$$

where r_1' , r_2' , etc., are the probable errors of the individual plates freed from their effect upon the mean. For $n = 12$, $r_0 = \pm 0.''022$.

TABLE VI.—MEAN X AND RESIDUALS FOR EACH PLATE.

Star.	X_m	12	13	14	15	16	17	18	19	20	21	22	23
1	-2658.52	+.01	-.07	-.20	-.15	+.04	+.09	"	-.06	+.01	+.08	+.10	+.12
2	-2061.74				+.02	-.12		+.17		-.05			
3	-2015.18	+.13	+.15	-.19	-.19	+.03	-.08	-.08	+.07	+.13	+.11	-.06	-.02
4	-1742.39	+.16	+.11	+.15	+.07	-.15	-.11	+.01	-.11	-.01	+.06	-.18	-.04
5	-1678.12	+.17	-.09	+.04	-.05	-.23	+.30	+.03	-.08	+.03	+.01	-.14	+.01
6	-1542.16	-.07	+.11	+.04	+.10	-.06	-.12	+.03	-.11	-.08	-.01	+.16	+.03
7	-1473.88	-.16		-.05	+.16	-.06	+.01	+.08		-.08	+.11		
8	-1343.30		-.06		-.12	+.04	+.10	-.13		-.04		+.28	-.04
9	-1254.33	+.09	-.06	-.07	+.03	.00	.04	-.08	+.18	+.12	-.10	-.07	+.04
10	-1198.46	+.12	-.01	+.06	+.05	+.06	-.01	-.07	+.08	+.04	-.10	-.11	-.12
11	-1155.21	+.30	-.07	-.22	+.04	-.01	-.03	-.06	+.06	+.16	-.24	-.02	+.11
12	-1142.37	-.05	-.03	+.33	-.24	-.02	-.09	-.09	-.02	-.01	+.13	-.03	+.09
13	-1107.46	-.10	+.06	+.09	+.09	+.06	-.13	+.05	-.03	-.01	.00	-.02	-.11
14	-1103.02	+.32	-.01	-.17	+.11	-.12	-.16	-.02	+.10	+.03	-.08	-.07	+.08
15	-1086.37		+.55	+.23	-.10	-.11		-.20		-.09	-.06	-.08	-.13
16	-1056.15				+.06	+.14		-.29		+.10			
17	-1049.78	-.15	-.63	-.16	+.13	-.02		-.13	+.01	+.08	+.12	+.27	-.09
18	-1016.27	+.06	-.10	-.01	+.09	.01	+.02	-.07	+.09	+.05	-.02	-.05	-.02
19	-958.08	-.17	-.09	+.02	+.12	+.10	+.03	.00		-.08	+.16	-.05	-.02
20	-866.69	+.02	+.07	-.01	+.06	+.01	+.06	-.03	-.01	+.05	-.06	-.05	-.07
21	-801.93	-.16	+.04	-.02	-.01	+.05	+.02	+.10	-.07	-.02	.00	.00	+.01
22	-771.81	-.11	+.11	-.01	+.01	+.11	+.11	-.01		+.02	-.01	-.05	-.21
23	-719.85		+.09	+.13	+.08	+.11	-.18	-.23	+.19	+.02	+.08	-.27	-.14
24	-701.99	+.02	+.17	-.11	-.17	-.10		-.10		-.12	-.15	+.22	+.30
25	-699.67	+.16	-.32	-.22	+.08	+.03	+.05	-.08	+.08	+.14	-.18	+.15	+.07
26	-682.02	-.09	-.01	.00	+.10	+.03	+.01	+.03	+.08	+.07	+.06	-.07	-.17
27	-629.61	+.12	-.03	-.22	.00	.00	-.20	+.13	+.09	+.12	-.04	-.05	+.08
28	-572.08	+.17	-.03	-.03	+.05	-.16	-.01	+.03	+.04	+.02	.00	-.09	+.01
29	-543.80	-.02	-.11	-.08	-.09	+.17	+.08	-.08	+.18	+.10	-.17	+.04	-.08
30	-497.17	.00	-.06	-.12	-.05	+.10	+.02	-.01	-.19	+.03	+.02	+.35	-.10
31	-487.56	.00	+.10	-.16	-.86	+.14	+.13	+.21	+.21	.00	+.12	+.13	+.02
32	-475.77	-.17	-.04	-.03	+.07	+.06	-.03	+.05	-.05	.00	+.04	-.12	+.17
33	-478.73		-.25	+.19	-.07	-.31	+.16	-.02	-.02	+.16	+.09	+.20	-.12
34	-463.75	-.40	-.09	+.25	+.08	+.14		-.03		+.07			
35	-445.14	-.02			-.16			+.03		+.15			
36	-442.30	-.20	-.06	-.09	-.03	+.02	+.07	+.07	+.08	+.03	-.14	+.30	+.01
37	-424.23	+.02	+.15	-.01	+.07	-.12	.00	+.05	+.08	+.11	+.16	+.01	-.51
38	-424.74	-.14	-.23	-.13	-.10	-.24	-.08	+.09	+.19	+.24	+.13	+.14	+.11
39	-408.85	+.18	-.04	+.03	-.01	-.05	-.04	+.02	.00	+.02	-.10	+.06	-.05
40	-373.68	-.08	+.05	+.06	+.15	+.09	-.01	-.05	+.04	-.08	-.12	+.05	-.06
41	-364.86		-.02	-.08	-.15	+.05		-.24		-.04			
42	-358.24	-.16	-.05	+.01	+.04	+.02	+.05	-.02	-.03	-.01	-.08	+.15	+.09
43	-354.42	-.18	+.04	+.22	+.06	-.03	.00	+.06	+.03	-.09	+.08	-.01	-.11
44	-336.22	-.24	+.04	+.24	+.03	+.14	-.09	+.12	.00	+.04	-.08	+.06	-.23
45	-306.85	-.21	-.32	+.26	.05	+.25	+.32	-.11		+.02	-.20		
46	-271.14	-.14	+.11	+.09	+.07	+.14	-.12	+.08	-.02	-.14	+.01	-.09	-.02
47	-255.81	+.14	-.18	-.07	-.05	-.07	+.09	+.11	+.19	-.20	+.07	+.05	+.04
48	-245.99	+.09	-.04	+.06	-.10	-.05	.00	-.02	+.01	+.03	+.12	+.07	-.15
49	-215.28	-.06	-.03	+.11	+.03	+.02	+.06	-.06	-.05	-.02	-.06	+.08	-.03
50	-211.65	-.12	+.01	-.12	+.10	+.06	+.08	-.06	+.06	+.04	+.07	+.12	-.23

TABLE VI.—MEAN $\bar{Y}$ AND RESIDUALS FOR EACH PLATE.

Star.	$\bar{Y}_m$	12	13	14	15	16	17	18	19	20	21	22	23
1	+1234.91	-.17	+.09	.03	+.03	+.04	-.15	"	+.06	+.05	-.04	-.06	+.16
2	-2102.40				+.15	+.03		-.01		.18			
3	-882.79	-.04	-.03	.05	+.11	+.14	-.09	-.03	-.09	-.02	+.09	-.01	-.14
4	+2129.51	-.02	-.15	+.05	-.05	+.11	+.11	+.01	+.14	+.02	-.01	-.02	-.13
5	+895.57	-.08	+.15	+.09	-.07	-.19	+.08	-.06	+.11	-.05	-.03	+.01	-.02
6	+2063.14	+.08	+.03	-.01	-.05	+.02	-.03	-.04	+.07	+.02	-.13	+.07	-.06
7	+1599.50	-.20		+.21	+.02	+.03	+.03	-.11		-.01	-.01		
8	-2461.04		+.14		-.02	+.01	+.28	-.20		.08		-.08	.02
9	-1562.45	-.05	-.10	-.07	-.13	+.01	+.10	-.03	+.11	+.02	+.11	-.03	+.05
10	-512.58	+.02	.00	-.15	+.02	+.09	-.07	+.08	+.05	+.01	-.02	-.04	+.08
11	-419.22	.04	-.25	-.07	+.08	+.03	-.03	+.13	-.04	+.15	-.15	+.08	+.09
12	-1082.80	-.32	-.02	+.05	+.40	+.07	+.15	-.05	-.03	+.04	-.11	+.02	-.21
13	-149.22	.00	+.10	-.08	-.04	+.08	-.23	-.01	+.11	-.09	-.04	-.10	+.08
14	-1630.38	.00	-.17	.06	+.09	+.05	+.04	+.07	+.15	.03	+.04	.13	-.06
15	-259.10		+.12	+.02	-.10	-.11		-.17		+.06	+.28	-.02	-.11
16	-1424.39				+.07	-.04		.00		-.04			
17	-730.62	-.01	+.13	-.04	+.07	+.05		+.09	-.04	+.12	-.09	-.25	-.08
18	-1446.60	-.10	-.02	+.10	-.04	-.02	+.10	-.04	+.06	+.01	-.03	.00	+.04
19	-984.52	+.07	-.04	-.06	-.02	-.08	+.01	-.04		+.10	+.02	+.03	.00
20	+700.94	+.11	-.03	+.16	-.07	-.19	-.04	+.01	+.03	-.02	+.02	+.03	-.06
21	-308.10	+.09	-.10	+.19	-.06	-.15	-.03	-.05	+.15	-.06	+.05	+.04	.00
22	+101.35	+.10	.00	+.01	-.06	-.01	+.01	+.10		-.02	+.01	-.07	-.11
23	-975.95		.00	+.19	-.09	-.05	+.02	-.03	+.07	-.04	-.06	-.10	+.05
24	+838.77	-.19	+.09	+.39	-.40	+.06		+.06		+.09	+.12	-.19	-.04
25	-1906.88	+.02	-.04	-.10	-.02	-.02	+.09	-.01	+.08	-.08	-.08	-.06	+.17
26	-290.17	+.14	-.01	+.12	-.16	-.02	-.01	+.04	-.06	+.01	-.03	-.01	+.06
27	+2623.68	+.19	-.09	.00	+.12	+.02	+.01	-.07	+.08	+.01	-.16	+.07	-.16
28	+1244.03	-.02	-.07	+.03	+.04	+.12	.01	-.07	+.06	-.03	-.06	+.10	-.12
29	-2488.93	+.09	+.04	.19	+.14	+.01	+.12	+.05	-.02	-.08	-.16	+.02	+.14
30	+676.58	-.09	+.03	+.31	.20	+.06	+.06	+.12	+.11	-.06	+.04	-.25	-.14
31	+1154.75	+.06	+.08	-.29	.02	.09	+.05	+.02	+.10	-.03	+.01	+.23	-.04
32	+2329.53	+.07	-.03	-.01	-.04	+.01	-.02	-.05	-.09	+.10	+.05	+.19	-.07
33	+1.92		-.06	-.04	-.07	.35	+.31	+.16	+.05	.09	-.03	.04	+.10
34	+137.08	+.05	+.01	-.03	-.02	.00		+.02		.06			
35	+239.78	-.04			+.07			+.08		-.09			
36	-1151.72	-.06	+.18	-.13	+.01	+.02	-.08	+.02	-.04	-.04	+.03	+.11	+.03
37	-1020.05	-.06	-.23	+.08	+.01	+.02	+.19	-.07	-.04	+.10	+.04	-.01	-.04
38	-2170.54	+.20	-.02	+.02	+.01	+.04	+.10	-.14	-.21	-.16	.01	-.21	-.06
39	-576.85	+.04	+.01	-.06	-.17	+.02	+.06	+.03	-.01	+.10	-.05	.00	.00
40	+136.99	+.03	-.02	+.11	.00	.03	-.18	-.05	+.03	-.06	+.06	+.09	-.02
41	+706.53		-.03	+.26	-.11	-.08		+.16		-.19			
42	-69.90	+.21	+.11	-.12	.00	.04	-.10	+.05	-.02	-.01	-.02	-.13	.00
43	+1397.97	+.06	-.20	-.29	-.16	+.18	+.11	+.04	-.17	+.22	-.07	+.07	+.13
44	+146.84	-.09	+.17	.16	+.03	-.07	-.07	+.01	+.07	+.04	+.04	+.14	-.07
45	-1073.62	-.05	.22	+.46	-.11	-.05	+.13	.14		-.13	+.10		
46	-249.11	+.08	+.12	+.01	+.01	-.12	-.19	-.01	+.02	+.07	-.04	-.04	+.10
47	-2858.42	+.12	-.12	-.08	+.06	-.01	.01	+.01	-.18	+.02	+.06	-.12	+.26
48	-1471.38	-.01	+.06	+.03	+.02	-.18	+.07	-.04	-.01	.05	+.03	.00	+.06
49	+416.31	-.03	+.06	+.06	.00	-.23	.00	+.04	+.06	-.08	+.02	+.19	-.02
50	-124.92	-.10	+.02	-.02	+.08	.00	+.03	-.05	+.05	+.05	+.02	+.05	-.14

TABLE VI.—MEAN X AND RESIDUALS FOR EACH PLATE.—
Continued.

Star.	X_m	12	13	14	15	16	17	18	19	20	21	22	23
51	— 210.73	— .03	— .10	— .01	— .03	— .09	— .08	— .12	— .05	— .16	— .03	— .40	— .16
52	— 207.71	— .10	+ .04	+ .22	+ .04	+ .15	+ .02	— .09	— .04	— .17	— .06	— .02	— .00
53	— 196.27	— .05	— .24	+ .13	+ .04	+ .02		— .25	— .29	— .12	— .09	+ .12	+ .14
54	— 162.21	— .01	— .24	+ .24	— .13	— .06	+ .04	— .15	+ .03	— .07	— .10	— .27	— .05
55	— 159.28				+ .20	+ .03		— .22		.00			
56	— 120.78			— .26	— .04	+ .01	.00	— .05	+ .17	— .01	— .08	+ .08	+ .13
57	— 110.92		— .27	+ .21	+ .12	+ .05	— .08	+ .30	— .24	— .05	+ .10	— .17	— .01
58	— 106.50					+ .04							
59	— 99.86					+ .11		+ .20		— .31			
60	— 75.72	+ .18	+ .14	+ .22	— .08	— .12	— .14	— .10	— .02	— .07	— .08	— .10	— .03
61	— 59.37	— .27	+ .34	+ .09	+ .02	+ .08	— .09	+ .06	— .09	+ .13	— .17	— .07	— .06
62	— 36.82		— .02	— .07	+ .22	— .14	+ .08	+ .02	+ .05	— .02	— .17	— .08	+ .09
63	— 27.72	+ .09	+ .04	+ .20	— .07	— .05	— .07	— .06	+ .01	— .06	— .05	— .11	— .15
64	— 26.83	— .04	+ .08	— .15	+ .02	+ .04	— .04	+ .06	+ .03	— .04	— .09	— .06	— .02
65	— 20.47	— .20	+ .14	— .05	— .05	+ .12	— .20	— .05	— .30	— .10	— .07	— .24	+ .29
66	— 0.61	— .15											
67	0.00	+ .17	— .05	— .09	+ .10		+ .14	+ .15		+ .30			— .43
68	+ 26.00				— .05	+ .37		— .06		— .26			+ .10
69	+ 106.30	— .20	+ .18	— .13	— .01	— .02	+ .05	+ .12	+ .02	+ .01	— .02	— .03	+ .06
70	+ 111.30	— .12	.00	+ .08	+ .12	— .01	+ .07	— .03	— .15	+ .09	— .04	+ .01	— .02
71	+ 194.42		— .13	+ .06	— .01	+ .01	— .12	+ .05	— .05	+ .10	— .05	+ .08	+ .06
72	+ 199.73		— .09		.00	+ .08	— .15	+ .03		+ .01	+ .10		
73	+ 200.62	+ .08	— .09	— .15	+ .11	— .06	— .08	— .07	+ .02	+ .08	— .09	+ .01	+ .26
74	+ 216.22	— .07	+ .10	— .22	— .08	— .19	+ .34	— .11	— .02	— .04	— .09	+ .22	+ .10
75	+ 244.46	+ .14	+ .07		+ .01	+ .02	— .04	— .09		— .17	+ .12		— .08
76	+ 242.82		— .27	— .40	+ .10	— .06		+ .02	+ .16	+ .18	+ .26		
77	+ 304.45		+ .03	— .53	— .07	+ .08	+ .09	+ .23		— .03	+ .20		
78	+ 335.38	+ .14	+ .05	+ .02	— .04	— .02	— .06	+ .02	.00	— .03	+ .02	— .07	— .02
79	+ 426.68	— .15	+ .05	— .06	— .13	+ .11	— .05	+ .12		— .05	+ .16		— .14
80	+ 442.62	— .05		+ .16	+ .06	— .26	+ .07	— .04			+ .07		
81	+ 508.57	+ .07	— .13	+ .24	— .04	— .10		+ .03		— .13	+ .06		
82	+ 506.35	— .08	+ .06	+ .01	+ .05	— .02	— .12	+ .07	— .02	— .19	+ .12	+ .02	+ .12
83	+ 651.98		— .06	+ .14	.00		— .07	+ .15	— .13	+ .15	+ .03	— .20	+ .01
84	+ 703.24		— .01	+ .12				.00			— .02		— .10
85	+ 683.22	+ .05	+ .06	— .26	— .07	+ .10	+ .08	+ .04	— .04	.00	— .11	— .06	.00
86	+ 784.36	— .08	— .04	+ .08	— .07	+ .11	— .01	+ .03	— .08	+ .08	— .11	— .17	.00
87	+ 820.34	+ .16	+ .06	+ .08	— .15	— .02	— .01	+ .01	— .04	— .06	— .04	— .10	— .07
88	+ 924.94	— .14	— .05	+ .12	+ .07	— .06	+ .12	— .12	— .12	— .02	— .10	— .19	— .07
89	+ 962.36	+ .15	— .04	— .04	— .10	— .07	+ .06	+ .03	— .03	— .02	— .01	— .11	— .13
90	+ 968.17	+ .09	+ .12	+ .09	— .03	— .02	— .02	— .05	— .05	— .15	— .03	— .11	— .02
91	+ 978.53	— .03	+ .14	— .15	+ .02	+ .04	+ .10	+ .10	— .02	— .15	+ .12	— .16	— .04
92	+ 1002.50	+ .16	+ .12	+ .16	— .10	.00	+ .32	— .02	+ .01	— .14	— .01	— .28	— .21
93	+ 999.84		— .09	+ .07	— .08	+ .05	— .18	.00		— .03	+ .28		
94	+ 1099.25	+ .19	— .23	— .08	+ .11	— .04	+ .02	— .13		— .17	+ .09		+ .25
95	+ 1143.32	+ .09	.00	+ .20	— .05	+ .04	+ .12	— .01	— .07	— .14	+ .04		— .24
96	+ 1200.96				+ .09	— .37	+ .01	— .12		— .37			
97	+ 1218.63	— .16	+ .02	— .02	.00	— .13	+ .12	+ .01	+ .03	+ .01	— .09	+ .21	— .02
98	+ 1251.30		+ .61		— .25	— .26		— .11					
99	+ 1258.71	— .05	— .07	+ .22	+ .09	.00	— .04	— .01	— .02	+ .01	— .07	— .14	+ .12
100	+ 1293.07		— .09		+ .02	+ .13	+ .11	— .13	— .05	— .05	— .08	— .26	

TABLE VI.—MEAN Y AND RESIDUALS FOR EACH PLATE.—*Continued.*

Star.	Y_m	12	13	14	15	16	17	18	19	20	21	22	23
51	+ 253.33	-.05	-.01	-.16	-.12	+.16	+.21	-.00	-.13	-.02	-.04	+.18	-.04
52	- 369.41	+.05	-.10	+.08	-.08	-.07	.00	+.02	+.05	+.01	+.03	-.06	+.06
53	- 261.45	-.02	-.23	+.14	+.20	-.34		+.06	+.17	-.03	+.09	+.01	-.01
54	- 108.80	-.25	-.15	+.21	+.06	+.05	-.23	+.04	-.07	+.06	+.14	+.14	-.07
55	- 41.50				-.07	-.12		-.06		-.01			
56	- 88.37			+.22	+.04	-.06	+.03	+.10	+.04	-.03	+.12	-.39	-.10
57	- 86.30		+.11	-.02	+.12	-.11	-.22	+.29	-.16	+.04	+.21	-.27	+.03
58	- 343.00					-.02		+.03					
59	+ 32.84					+.09		-.06					
60	- 122.32	-.10	-.11	+.12	+.01	+.04	-.06	+.03	-.08	-.04	+.18	+.03	-.05
61	- 156.13	+.03	-.01	.00	+.04	-.02	-.11	+.09	+.04	-.03	+.10	-.24	+.11
62	- 123.31		+.18	+.20	+.05	-.05	-.02	-.08	+.01	.00	+.04	-.26	-.07
63	- 152.04	+.12	-.05	-.05	+.05	-.07	-.07	-.02	+.01	.00	+.07	-.01	-.03
64	- 139.43	+.02	-.01	-.14	-.14	+.09	+.10	-.04	+.03	+.06	+.01	+.06	.00
65	- 519.71	-.14	-.11	+.07	+.31	+.30	+.08	-.03	+.06	-.03	-.14	-.35	.00
66	- 145.76	-.16				+.14		+.02		-.08			+.06
67	0.00	.00	-.07	+.01	+.02	+.06	.00	-.05	+.06	-.01	.00	+.03	-.04
68	+ 288.76				+.04	+.08		-.27		+.13			
69	- 325.76	+.01	-.06	+.37	-.10	-.06	-.20	.00	-.17	-.05	+.10	+.19	-.06
70	- 110.22	+.14	+.10	-.06	-.03	-.06	-.08	+.03	+.02	-.01	+.13	-.03	-.10
71	+ 181.65		-.08	-.11	+.05	+.03	-.03	+.05	+.06	+.01	+.08	-.07	-.03
72	+ 366.50		+.04		+.04	+.15	-.35	+.07		-.02	+.05		
73	- 1201.62	+.13	-.08	.10	-.13	.00	+.02	-.06	-.11	.00	.01	+.18	.00
74	- 275.30	-.07	-.09	+.12	+.04	+.03	+.31	-.01	-.17	-.13	+.06	-.01	-.04
75	- 1627.78	+.11	-.26		+.09	-.06	+.16	+.18		-.14	-.02		-.08
76	- 680.26		-.13	+.09	+.01	+.14		-.15	+.13	-.04	-.05		
77	- 2858.48		-.21	-.27	+.01	+.11	+.58	-.14		-.05	.00		
78	+ 541.04	+.06	+.08	-.02	-.04	-.02	-.08	+.04	-.01	-.01	+.04	-.01	-.03
79	- 2073.59	+.11	-.28	-.07	+.14	-.03	+.15	-.01		-.07	-.03		+.14
80	+ 1075.46	+.50		+.23	-.27	-.14	-.31	-.05			+.07		
81	- 1538.34	+.14	-.09	+.25	-.35	+.09		+.02		+.03	-.05		
82	- 247.25	-.02	+.10	+.10	-.13	-.15	-.04	+.09	.00	+.02	-.04	-.01	+.07
83	+ 2306.91		-.17	+.07	+.08		-.13	-.05	-.04	+.07	+.03	+.02	+.16
84	- 3012.03		-.07	-.18				-.03			+.07		+.21
85	+ 523.51	.00	+.11	-.20	+.09	-.09	+.03	-.02	+.05	+.04	+.03	-.12	+.06
86	+ 1049.00	-.12	+.23	+.14	-.01	-.11	-.18	-.06	+.25	-.02	-.07	+.01	-.03
87	- 864.33	-.05	-.06	+.07	-.01	-.14	-.07	-.01	+.08	+.02	+.06	+.11	.00
88	+ 5.51	-.10	-.04	+.04	+.02	-.04	-.01	+.07	-.04	-.04	+.07	-.09	+.02
89	- 1254.30	-.02	+.14	.00	-.11	+.02	.00	-.05	+.05	-.08	+.03	-.08	-.07
90	- 1078.03	-.02	+.11	+.01	-.01	+.03	+.09	.00	.01	-.21	-.05	-.01	+.07
91	- 1120.06	-.01	-.09	-.01	-.05	+.09	+.02	+.02	+.05	-.03	+.05	+.01	-.06
92	- 70.79	-.04	+.27	-.31	-.09	+.17	+.02	+.11	-.17	-.03	-.08	-.02	+.12
93	+ 508.73		+.20	+.16	+.10	+.07	-.31	+.05		-.14	-.12		
94	+ 1455.92	+.33	-.20	-.30	+.06	-.09	-.13	+.04		+.09	+.17		+.01
95	+ 476.78	+.07	-.10	-.17	-.06	.00	-.04	-.05	-.02	+.11	-.02		+.33
96	+ 521.23				-.02	-.01	-.02	-.12		+.16			
97	- 136.25	+.09	+.17	-.12	-.05	-.16	+.03	-.02	-.02	-.05	+.04	+.02	+.08
98	- 711.82		+.38			+.12	-.38	-.09					
99	+ 803.74	+.14	+.11	-.19	-.04	-.05	-.07	-.02	+.02	-.01	+.08	-.07	+.13
100	+ 11.43		-.04		+.10	+.09	+.10	-.08	+.09	+.10	-.43	+.10	

TABLE VI.—MEAN X AND RESIDUALS FOR EACH PLATE.—
Concluded.

Star.	X_m	12	13	14	15	16	17	18	19	20	21	22	23
101	+1317.59	"	+.11	-.17	+.02	+.13	"	.00	"	-.03	"	"	-.09
102	+1309.21	+.01	-.15	-.01	+.07	-.05	.00	+.07	-.08	+.09	+.04	-.04	+.03
103	+1307.43	+.04	+.01	-.04	+.04	+.12	-.02	-.08	-.07	+.07	-.02	-.11	+.10
104	+1315.38				-.18			.00		+.17			
105	+1342.13				-.10	+.10		*					
106	+1370.85			+.09	-.06	+.23	-.19	.00		-.04	-.03		
107	+1356.94	+.18	+.02	-.01	+.04	+.11	-.01	-.07	+.03	-.02	-.08	-.09	-.12
108	+1360.46	+.13	-.06	-.04	-.10	+.15	+.02	-.03	-.04	-.08	+.15	+.25	-.32
109	+1375.24	+.09	-.15	+.05	+.01	-.06	+.02	+.02	+.05	+.19	+.04		-.31
110	+1409.07	-.03	+.15	-.02	-.05	+.06	+.05	-.13	+.08	+.02	-.03	+.01	-.07
111	+1433.30	+.01	+.08	+.03	-.05	+.03	+.17	-.06		+.11	+.04	+.08	-.31
112	+1415.02	+.09	-.07	-.01	-.04	+.14	+.01	+.04	-.02	-.04	-.04	+.06	-.10
113	+1423.68	-.09	+.12	+.14	-.12	+.03	+.04	-.05	-.03	-.04	+.02	+.08	-.06
114	+1452.22		-.28		+.04	-.01		+.27		-.02			
115	+1433.46	-.07	-.05	-.15	+.05	-.06	-.13	+.14	-.02	-.06	+.06	+.24	+.05
116	+1479.66	+.05	-.12	.00	-.01	+.12	+.03	+.06	-.01	.00	-.04	-.02	-.10
117	+1469.03		+.17	+.60	-.13	+.04	-.25	-.26			-.20		
118	+1498.04	-.03	-.09	+.09	-.08	-.02	-.05	-.05	+.01	+.01	+.08	+.18	-.06
119	+1525.52	+.07	-.28	+.19	-.11	-.06	-.07	-.13		-.01	+.08	+.12	+.20
120	+1589.62	+.05	+.04	-.05	+.08	-.09	+.02	-.01	+.05	+.03	.00	-.02	-.12
121	+1653.14	+.02		+.09	.00	+.05	+.02	-.07	-.03	+.02	-.11		+.03
122	+1711.60	+.13	-.06	-.13	+.11	-.06	-.10	-.02	.00	+.12	+.10	-.05	-.03
123	+1724.56	+.01	-.02	-.02	+.10	+.02	+.20	-.09	-.07	-.07	+.02	+.02	-.08
124	+1749.88	+.04	-.07	+.07	+.08	-.51	-.04	-.09	+.40	+.02	+.15		
125	+1778.36	.00	+.02	+.09	+.05	+.03	-.14	+.06	-.05	+.10	-.18	-.06	+.09
126	+1841.46		+.13		-.21	+.12	-.24	+.04		+.09	-.28		+.38
127	+1825.74	-.23	+.07	-.04	+.06	-.05	+.10	-.02	-.04	-.11	+.14	+.13	-.07
128	+1821.48	+.06	+.06	-.26	+.05	-.22	+.01	+.06	-.02	-.04	.00	-.01	+.30
129	+1876.12				+.15	-.14		.00		+.24	-.27		
130	+1904.95	+.04	-.05	-.15	+.13	.00	+.16	-.05	-.07	+.08	-.07	-.18	+.08
131	+1932.37	+.18	+.01	+.08	+.03	+.01	+.18	+.01	-.15	-.01	-.08	-.26	-.04
132	+1959.63			-.06	-.04	+.10	-.11	-.03			+.16		
133	+2063.50	+.02	+.08	-.01	-.10	-.04	-.05	+.11	+.03	-.02	+.02	-.11	+.12
134	+2113.54				+.04	-.12	-.08	-.05		+.09			+.14
135	+2186.15		+.12	+.03	+.05		-.05	-.03	-.13	+.13			-.11
136	+2168.79	-.41	-.24	+.50	+.14	.00	-.20	+.11	.00	+.06	+.18	-.34	+.14
137	+2199.48		-.01	+.20			-.18						
138	+2298.04				+.03	-.04							
139	+2325.52		+.08	+.24	-.11	-.08	-.26	-.15		+.28			
140	+2324.49	-.05	+.07	-.10	+.08	-.06	-.16	-.14	+.08	+.02	+.09	-.16	+.33
141	+2488.23			-.11	-.11		-.12	-.12					+.46
142	+2501.26		+.09	+.06			-.15						
143	+2638.31	+.11	-.12	-.02	.00	+.02	-.03	-.11	.00	-.10	-.06	-.06	+.31
144	+2701.79		+.18		-.02			-.18		+.03			
145	+2668.26	-.02	+.11	+.21	+.19	+.02	-.43	+.05		-.13	+.05		.00

TABLE VI.—MEAN Y AND RESIDUALS FOR EACH PLATE.—*Concluded.*

Star.	Y_m	12	13	14	15	16	17	18	19	20	21	22	23
101	-2115.36	"	-.09	+.10	+.10	+.27	"	-.06	"	-.07	"	"	-.26
102	-929.14	-.14	+.09	-.06	-.06	+.05	+.08	-.04	+.01	+.08	+.02	.00	+.02
103	+287.55	+.07	-.06	-.10	+.06	-.01	-.05	-.04	+.06	+.04	-.01	-.04	+.07
104	+634.94				+.02			+.09		-.12			
105	-1625.94				+.17	-.18							
106	-2678.09			-.05	-.01	-.14	+.23	-.08		.15	+.23		
107	-64.16	-.02	+.06	.10	+.09	-.10	+.06	+.07	+.01	+.04	-.07	+.02	-.04
108	-91.63	-.12	+.03	+.08	+.06	.00	-.08	+.11	.00	.00	-.01	-.22	+.14
109	-80.65	+.04	-.11	-.03	+.12	-.02	+.18	+.07	+.08	-.07	-.16		-.15
110	-259.91	-.10	+.12	+.45	-.07	.00	+.21	-.10	+.02	-.02	-.12	-.36	-.10
111	-2298.36	-.19	-.17	+.08	-.01	+.04	+.05	-.09		-.11	-.20	+.28	+.31
112	-182.53	-.03	+.11	.00	+.02	+.01	-.05	-.04	-.05	-.01	+.07	+.03	-.02
113	-136.21	-.10	-.10	-.23	+.12	+.04	-.02	-.03	+.08	.00	-.02	+.02	+.02
114	-2009.71		+.06			+.01	+.19			-.22			
115	-162.04	-.04	-.09	+.20	+.02	+.13	.00	+.02	-.01	-.10	.00	-.02	-.12
116	+395.86	+.02	+.01	+.02	.00	.00	-.09	+.08	+.01	.00	-.02	-.02	.00
117	+1649.68		-.12	+.04	+.10	-.04	-.03	+.22			-.16		
118	-138.24	-.08	-.11	+.09	+.07	+.10	-.01	-.04	-.09	-.04	-.01	+.14	-.03
119	+443.03	+.37	+.13	-.15	+.08	-.11	+.02	+.01		-.13	+.04	-.25	-.01
120	+168.25	+.04	+.11	-.14	-.09	+.02	-.05	-.03	-.05	+.07	-.09	+.05	+.11
121	-284.88	+.22		-.19	-.02	+.02	+.02	-.04	-.06	-.03	+.02		+.09
122	-265.29	+.04	+.07	-.06	.00	-.09	+.02	-.03	+.02	-.02	-.06	+.10	+.01
123	+1265.32	+.11	+.01	-.24	-.01	+.08	+.06	-.06	+.12	-.02	-.04	+.02	-.04
124	-22.76	+.07	+.21	-.08	-.08	+.20	-.16	-.08	-.17	+.07	.00		
125	+306.64	+.01	.00	-.03	+.07	+.08	-.02	+.07	-.02	+.01	-.02	-.04	-.14
126	-1931.06		-.09		-.02	-.09	+.15	-.05		+.01	+.07		+.02
127	-526.76	+.03	+.03	+.28	+.09	-.05	+.06	-.04	-.27	-.06	-.01	-.05	+.02
128	+818.72	-.18	+.05	-.03	+.08	-.14	-.03	+.05	-.03	+.09	+.01	+.03	+.10
129	-114.83				+.08	-.19		-.20		+.11	+.18		
130	+1127.11	+.08	-.09	+.04	.00	-.08	.00	-.08	+.03	+.14	+.02	-.20	-.03
131	+47.76	-.02	+.07	+.02	.00	-.08	-.10	.00	-.04	-.03	+.06	+.06	+.06
132	+1316.72			-.13	+.19	+.05	+.15	-.02			-.24		
133	-1093.22	-.06	+.11	+.16	-.02	+.06	.00	-.06	-.10	-.05	-.03	+.02	-.01
134	+217.04			-.01	+.13	+.06	-.11			-.13			+.05
135	-2098.16		+.02	+.02	-.03		+.18	-.04		-.25			
136	-996.61	+.05	-.08	+.13	+.03	+.13	-.07	-.04	-.18	+.04	.00	+.14	-.14
137	+2492.32		-.05	+.13			-.07						
138	+292.48				+.06	-.05							
139	+483.40		+.08	-.06	+.06	+.02	-.04	-.04		-.04			
140	+713.54	-.06	-.05	-.04	+.14	+.05	-.01	+.04	-.03	+.07	-.12	+.02	+.06
141	+2017.24			+.06	+.01		-.23	+.29					-.15
142	+2036.00		+.09	+.23			+.15						
143	+229.01	+.10	-.22	-.02	+.04	+.07	+.07	+.07	-.15	+.01	+.09	-.18	+.12
144	-576.03		-.16		+.23			-.06		.00			
145	+1121.43	-.03	+.08	+.06	+.13	+.15	+.16	-.05		-.05	-.32		-.16

VI. STANDARD COÖRDINATES.

Thus far the results have been independent of any catalogue positions of the stars. In order to obtain standard coördinates the axes must be rotated so as to bring the y -axis exactly into the plane of a declination circle, and the scale-value and position of the origin must be determined so as to agree with the right ascensions and declinations of known stars. In other words, we must compare the mean plate with an ideal plate whose axes are oriented for the position of the equinox at the epoch selected and upon which the star-places correspond to those of the catalogue chosen.

We have used for this purpose the results of heliometer measures made by Schur at Göttingen during the years 1890–96.¹ Twelve of the fifteen stars of his triangulation are found upon the plates and suffice to give a very good determination of plate constants. There is, however, one difficulty connected with their use, namely, proper motion. This may become sensible in the interval of nineteen years between the date of the photographs and that of the heliometer measures. Schur has given proper motions for two of these stars (l and m of his catalogue) taken from Auwers' Bradley. A preliminary determination of the constants for each plate based upon Schur's places (including the proper motions given for l and m) led us to question that assigned to l . The residuals in both right ascension and declination were notably larger than those for other stars and were of the same sign for all plates. A re-determination of constants was made for two or three plates, using Schur's position for l unaffected by proper motion. This resulted in a marked reduction of residuals for l , while the probable error of a single equation of a solution depending entirely upon the eleven other stars was only about one half of the probable error first found.

¹ *Astronomische Mittheilungen von der Königlichen Sternwarte zu Göttingen*, Theil 6, 1900.

Such catalogues as were easily accessible were then examined to find whether the proper motion given by Schur was confirmed. Positions of the star were found in fourteen different catalogues and were reduced to the year 1875.0. Systematic corrections were applied to reduce these to the system of the Fundamental Catalogue in all cases where the catalogue was found in one of Auwers' lists.¹ No correction was made to the other catalogue places, but a separate solution was made excluding such places and their effect upon the result was found to be comparatively small. The various observations were weighted according to the "Table of Weights" given by Davis in "Declinations and Proper Motions of Fifty-six Stars." A single observation was found in Lalande² and was reduced by Von Asten's tables. The observation of right ascension was given zero weight as the times given for transit over the two wires were inconsistent with the known interval.

Three values were determined for proper motion: (a) from all the observations, (b) excluding Bradley and Lalande, (c) excluding also catalogue places for which systematic corrections were unknown.

Solutions by the method of least squares gave the following results:

$$\begin{aligned}
 (a) \quad \mu_{\alpha} &= -0^{\circ}.0027 \pm 0^{\circ}.0012, \\
 \mu_{\delta} &= -0''.015 \pm 0''.009; \\
 (b) \quad \mu_{\alpha} &= -0^{\circ}.0024 \pm 0^{\circ}.0013, \\
 \mu_{\delta} &= -0''.019 \pm 0''.010; \\
 (c) \quad \mu_{\alpha} &= -0^{\circ}.0032 \pm 0^{\circ}.0018, \\
 \mu_{\delta} &= -0''.024 \pm 0''.014.
 \end{aligned}$$

The corresponding values given by Schur are

$$\mu_{\alpha} = -0^{\circ}.0037; \mu_{\delta} = +0''.02.$$

Not wishing to consider any one of these values definitive, it was decided to omit the star *l* from the list of standards.³

We give on the following page the positions of the eleven stars for the epoch 1893.75 and the mean equinox of 1890.0.

¹ *Astron. Nach.*, 3195-96, 3413-14.

² *Histoire Céleste Française*, Tome Premier, p. 371.

³ A comparison of our final catalogue position with Schur's gives $\mu_{\alpha} = -0^{\circ}.0006$; $\mu_{\delta} = -0''.006$.

The number given is the number in our catalogue, the letters are Schur's. No. 67 is the central star.

Star.		α 1870.0.			δ 1890.0.		
		<i>h</i>	<i>m</i>	<i>s</i>	<i>o</i>	<i>'</i>	<i>''</i>
11	<i>a</i>	2	9	10.477	+56	32	35.06
19	<i>b</i>		9	34.737		23	11.21
39	<i>c</i>		10	40.779		30	0.98
40	<i>d</i>		10	44.886		41	54.73
67	<i>e</i>		11	30.237		39	37.93
78	<i>f</i>		12	11.145		48	38.09
82	<i>g</i>		12	31.519		35	29.12
90	<i>i</i>		13	26.604		21	35.55
101	<i>k</i>		14	7.833		24	1.19
128	<i>m</i> ¹		15	12.596		53	2.12
133	<i>o</i>		15	38.363		21	6.48

For star *m* the correction for proper motion was applied to reduce its position to the epoch of 1874.4, the mean date of the plates.

From these right ascensions and declinations rectangular coördinates were computed for each star according to the formulas already given (pp. 31 and 32). These were compared with the corresponding X_m and Y_m of Table VI, giving for the determination of the plate constants equations of the form

$$\begin{aligned} pX + rY + k + (X_m - x) &= 0, \\ pY - rX + c + (Y_m - y) &= 0. \end{aligned}$$

The solution of these equations by least squares gave the following values:

$$\begin{aligned} p &= -0.000013 \pm 0.000021, \\ r &= +0.001184 \pm 0.000021, \\ k &= +0''.040 \pm 0''.028, \\ c &= -0''.043 \pm 0''.028, \end{aligned}$$

probable error of a single equation = $\pm 0''.0855$.

The residuals for the various stars expressed in arc of a great circle are as follows:

	v_x	v_y		v_x	v_y
	"	"		"	"
<i>a</i>	+0.12	+0.09	<i>g</i>	-0.05	-0.03
<i>b</i>	-0.07	-0.04	<i>i</i>	-0.05	-0.23
<i>c</i>	-0.03	-0.06	<i>k</i>	-0.05	-0.22
<i>d</i>	+0.02	+0.06	<i>m</i>	-0.01	+0.16
<i>e</i>	+0.04	-0.04	<i>o</i>	-0.08	+0.29
<i>f</i>	+0.15	+0.01			

¹ Proper motion, $-0''.0014$ in α , $+0''.01$ in δ .

Corrections to the X_m and Y_m of all stars were computed by means of these constants and the resulting standard coördinates are given in Table VII. If in the future definitive proper motions are determined for Schur's stars, corresponding corrections for the plate constants and these coördinates can be computed readily.

TABLE VII.—STANDARD COÖRDINATES.

Star.	X	Y	Star.	X	Y
1	—2656.99	+1238.00	51	—210.39	+253.54
2	—2064.16	—2099.97	52	—208.11	—369.20
3	—2016.16	—880.43	53	—196.54	—261.26
4	—1739.81	+2131.50	54	—162.30	—108.65
5	—1677.00	+897.51	55	—159.29	—41.35
6	—1539.66	+2064.90	56	—120.84	—88.27
7	—1471.93	+1601.19	57	—110.98	—86.21
8	—1346.15	—2459.46	58	—106.87	—342.91
9	—1256.12	—1560.98	59	—99.78	+32.92
10	—1199.01	—511.19	60	—75.82	—122.27
11	—1155.65	—417.88	61	—59.51	—156.10
12	—1143.60	—1081.48	62	—36.93	—123.31
13	—1107.59	—147.95	63	—27.86	—152.05
14	—1104.88	—1629.09	64	—26.96	—139.44
15	—1086.63	—257.85	65	—21.05	—519.71
16	—1057.79	—1423.16	66	—0.74	—145.80
17	—1050.60	—729.41	67	+0.04	—0.04
18	—1017.92	—1445.42	68	+26.38	+288.69
19	—959.20	—983.42	69	+105.95	—325.93
20	—865.81	+701.93	70	+111.21	—110.39
21	—802.24	—307.19	71	+196.61	+1819.36
22	—771.64	+102.22	72	+200.20	+366.22
23	—720.96	—975.13	73	+202.08	+1201.32
24	—700.95	+839.55	74	+215.93	—275.60
25	—701.88	—1906.07	75	+242.57	—1628.09
26	—682.31	—289.40	76	+242.05	—680.58
27	—626.45	+2624.36	77	+301.11	—2858.84
28	—570.56	+1244.65	78	+336.06	+540.59
29	—546.70	—2488.30	79	+424.25	—2074.11
30	—496.32	+677.12	80	+443.92	+1074.89
31	—486.14	+1155.27	81	+506.78	—1538.96
32	—472.96	+2330.02	82	+506.09	—247.89
33	—478.68	+2.45	83	+654.74	+2306.07
34	—463.54	+137.59	84	+699.70	—3012.86
35	—444.81	+240.27	85	+683.87	+522.65
36	—443.61	—1151.23	86	+785.63	+1048.02
37	—425.39	—1019.58	87	+819.35	—865.33
38	—427.26	—2170.05	88	+924.98	+4.37
39	—409.48	—576.40	89	+960.90	—1255.46
40	—373.48	+137.39	90	+966.92	—1079.21
41	—363.98	+706.91	91	+977.23	—1121.25
42	—358.28	—69.52	92	+1002.45	—72.02
43	—352.72	+1398.33	93	+1000.47	+507.50
44	—336.01	+147.20	94	+1101.00	+1454.56
45	—308.08	—1073.29	95	+1143.91	+475.38
46	—271.39	—248.83	96	+1201.60	+519.76
47	—259.15	—2858.12	97	+1218.49	—137.73
48	—247.69	—1471.11	98	+1250.48	—713.33
49	—214.75	+416.51	99	+1259.68	+802.20
50	—211.76	—124.71	100	+1293.10	+9.86

TABLE VII.—STANDARD COÖRDINATES.—*Concluded.*

Star.	X	Y	Star.	X	Y
101	+1315.11	-2116.93	124	+1749.87	-24.87
102	+1308.13	-930.72	125	+1778.74	+304.49
103	+1307.79	+285.96	126	+1839.19	-1933.25
104	+1316.15	+633.33	127	+1825.14	-528.95
105	+1340.22	-1627.55	128	+1822.47	+816.51
106	+1367.70	-2679.72	129	+1876.00	-117.09
107	+1356.88	-65.81	130	+1906.30	+1124.80
108	+1360.37	-93.28	131	+1932.44	+45.43
109	+1375.16	-82.32	132	+1961.20	+1314.34
110	+1408.78	-261.62	133	+2062.22	-1095.69
111	+1430.60	-2300.07	134	+2113.81	+214.50
112	+1414.82	-184.25	135	+2183.68	-2100.76
113	+1423.54	-137.94	136	-2167.62	-999.22
114	+1449.86	-2011.44	137	+2202.44	+2489.65
115	+1433.29	-163.78	138	+2298.40	+289.72
116	+1480.15	+394.06	139	-2326.10	+480.60
117	+1471.00	+1647.88	140	+2325.34	+710.74
118	+1497.90	-140.05	141	+2485.85	-2020.20
119	+1526.06	+441.17	142	-2503.68	+2032.97
120	-1589.84	+166.33	143	+2638.59	+225.85
121	+1652.82	-286.88	144	+2701.11	-579.26
122	+1711.31	-267.36	145	+2669.60	+1118.22
123	+1726.08	+1263.22			

VII. FINAL CATALOGUE.

Right Ascension and Declination. — The problem of determining the right ascension and declination of a star from its standard coördinates is the inverse of the one already solved.¹ Similar series are given for x' and y' in terms of x and y .²

These are, including terms of the third order :

$$\begin{aligned} x' = & x + xy \tan \delta \sin 1'' \\ & + xy^2 \tan^2 \delta \sin 1'' \\ & + x^3 \left[-\frac{1}{3}(1 + \tan^2 \delta) \right] \sin^2 1''. \end{aligned}$$

$$\begin{aligned} y' = & y + x^2 \left[-\frac{1}{2} \tan \delta \right] \sin 1'' \\ & + x^2 y \left[-\frac{1}{2}(1 + \tan^2 \delta) \right] \sin^2 1'' \\ & - \frac{1}{3} y^3 \sin^2 1''. \end{aligned}$$

By means of these formulas the standard coördinates of Table VII were transformed into differences of right ascension and declination. The positions of the catalogue were obtained by adding these differences to the right ascension and declination of the center of the plate. Right ascensions are given in both time and arc.

The values of the precession and secular variation were computed for each star and are included in the final catalogue, while in the last column will be found the mean epoch of the plates from which the positions given were determined.

Magnitudes. — These were obtained from measures of diameters of star-images upon Plates 15 and 18, these plates being selected because of the large number of stars found upon each. The results of these measures, expressed in revolutions of the micrometer, are given in Table VIII.

¹ See pages 31 and 32.

² See *Vierteljahrsschrift der Astronomischen Gesellschaft*, 1895, p. 114.

TABLE VIII.—DIAMETERS OF STAR-IMAGES.

Star.	Plate 15	Plate 18	Star.	Plate 15	Plate 18	Star.	Plate 15	Plate 18
	r	r		r	r		r	r
1	0.152 ¹	0.101	50	0.129	0.106	99	0.138	0.119
2	0.112	0.118 ²	51	0.125	0.084	100	0.108	0.102
3	0.149	0.110	52	0.141	0.113	101	0.128	0.108
4	0.176	0.142	53	0.121	0.098	102	0.171	0.131
5	0.115	0.107	54	0.118	0.109	103	0.272	0.217
6	0.150	0.113	55	0.103	0.095	104	0.122 ¹	0.094
7	0.106	0.091	56	0.132	0.096	105	0.087	
8	0.124	0.111	57	0.126	0.104	106	0.147	0.122
9	0.187	0.152	58	0.103	0.090	107	0.181	0.134
10	0.231	0.174	59	0.119	0.083	108	0.119	0.115 ²
11	0.297	0.208	60	0.288	0.201	109	0.104	0.085
12	0.121	0.091	61	0.120	0.101	110	0.120	0.100
13	0.142	0.113	62	0.129	0.101	111	0.134	0.104
14	0.227	0.166	63	0.131	0.107	112	0.164	0.123
15	0.105	0.101	64	0.152	0.110	113	0.131	0.104
16	0.106	0.102	65	0.114	0.099	114	0.151 ¹	0.093
17	0.097	0.087	66	0.104	0.112	115	0.124	0.101
18	0.170	0.126	67	0.266	0.196	116	0.156 ¹	0.109
19	0.135	0.105	68	0.130 ¹	0.089	117	0.111	0.110
20	0.192	0.143	69	0.113	0.110	118	0.118	0.108
21	0.121	0.089	70	0.123	0.095	119	0.119	0.093
22	0.123	0.107	71	0.136	0.108	120	0.116	0.099
23	0.105	0.095	72	0.113	0.098	121	0.115	0.097
24	0.117	0.090	73	0.128	0.101	122	0.127	0.118
25	0.184	0.138	74	0.117	0.102	123	0.141 ¹	0.120
26	0.145	0.114	75	0.114	0.112	124	0.114	0.099
27	0.244	0.201	76	0.105	0.102	125	0.194	0.159
28	0.246	0.183	77	0.114	0.107 ²	126	0.134 ¹	0.108
29	0.153	0.126	78	0.188	0.144	127	0.121	0.101
30	0.115	0.095	79	0.121	0.102	128	0.238	0.191
31	0.114	0.102	80	0.104	0.097	129	0.111	0.096
32	0.168 ¹	0.119	81	0.126	0.100	130	0.127 ¹	0.109
33	0.118	0.111	82	0.144	0.110	131	0.134	0.109
34	0.108	0.109	83	0.156	0.129	132	0.127	0.111
35	0.114	0.105	84	0.179	0.140	133	0.177	0.136
36	0.123	0.097	85	0.118	0.113	134	0.139	0.105
37	0.117 ¹	0.105	86	0.121	0.095	135	0.168 ¹	0.097
38	0.136	0.115	87	0.134	0.102	136	0.169 ¹	0.097
39	0.177	0.129	88	0.124	0.108	137	0.218 ¹	0.194 ²
40	0.201	0.129	89	0.117	0.102	138	0.135	
41	0.106	0.098	90	0.162	0.119	139	0.148 ¹	0.110
42	0.133	0.103	91	0.121	0.105	140	0.146 ¹	0.107
43	0.130	0.103	92	0.113	0.096	141	0.181 ¹	0.103
44	0.138	0.097	93	0.120	0.097	142	0.173 ¹	0.136
45	0.117	0.109	94	0.120	0.104	143	0.162 ¹	0.122
46	0.124	0.099	95	0.114	0.101	144	0.160 ¹	0.098
47	0.162	0.145	96	0.109	0.097	145	0.175 ¹	0.122
48	0.137	0.109	97	0.123	0.109			
49	0.128	0.106	98	0.082	0.095			

¹ Image elongated.

. Nebulous.

It was assumed that the relation between the measured diameter and the magnitude of a star can be expressed by Charlier's equation,

$$m = a - b \log D,$$

where m is the magnitude of the star, D is the diameter of the star-image, a and b are constants to be determined for the plate.

Each star of known magnitude gives an equation of this form and the solution of a series of such equations by the method of least squares will give values for a and b . These will not be the same for the two plates, because the diameters of images of the same star differ, being dependent upon atmospheric conditions and the sensitiveness of the plate as well as upon the length of exposure. They will also differ with the standards used. To illustrate this diversity we give the results of four solutions for each plate. The first rests upon Vogel's magnitudes¹ of twenty-five stars determined with a Zöllner's photometer. For the second the magnitudes of the Bonn *Durchmusterung* were used, for the third those of the stars found in the A. G. catalogue, and for the fourth photographic magnitudes of nineteen stars determined by Lohse in 1885.² For convenience in computation, D is expressed in these equations in hundredths of a revolution of the micrometer; *i. e.*, its value is one hundred times that given in Table VIII.

The equations are :

For Plate 15,

$$(1) \quad m = 16.07(\pm .37) - 6.38(\pm .33) \log D,$$

$$(2) \quad m = 15.37(\pm .23) - 5.63(\pm .20) \log D,$$

$$(3) \quad m = 15.30(\pm .37) - 5.67(\pm .31) \log D,$$

$$(4) \quad m = 12.36(\pm .95) - 2.93(\pm .88) \log D.$$

For Plate 18,

$$(1) \quad m = 16.40(\pm .45) - 7.18(\pm .43) \log D,$$

$$(2) \quad m = 16.26(\pm .26) - 6.97(\pm .25) \log D,$$

$$(3) \quad m = 15.41(\pm .40) - 6.33(\pm .36) \log D,$$

$$(4) \quad m = 11.36(\pm 1.26) - 2.15(\pm 1.25) \log D.$$

¹ H. C. Vogel. Der Sternhaufen χ Persei. Leipzig, 1878.

² O. Lohse. Über die photographische Aufnahmen χ Persei. *Astron. Nach.*, 2649-50.

Table IX shows the relation between magnitudes and diameters for these various values of α and b . In its columns are given the diameters which a star-image should have to correspond to the magnitude as given in the first column. It will be noticed that the first three solutions give very nearly the same results for stars between magnitudes 8.2 and 9.6, but that on either side of these limits the differences increase rapidly, especially for the brighter stars. Whatever the values of α and b used, these brighter stars will therefore be determined with less accuracy than those near the ninth magnitude. This was to be expected from the nature of the case.

TABLE IX.—FOR DETERMINING MAGNITUDES.

Mag.	Plate 15.				Plate 18.			
	Vogel.	A. G. C.	B. D.	Lohse.	Vogel.	A. G. C.	B. D.	Lohse.
	r	r	r	r	r	r	r	r
10.0	0.090	0.086	0.091	0.066	0.077	0.071	0.081	0.045
9.8	0.097	0.093	0.099	0.077	0.083	0.077	0.086	0.055
9.6	0.104	0.101	0.108	0.091	0.088	0.082	0.092	0.069
9.4	0.112	0.109	0.117	0.106	0.094	0.089	0.098	0.085
9.2	0.120	0.118	0.126	0.124	0.100	0.095	0.105	0.105
9.0	0.129	0.128	0.138	0.145	0.107	0.103	0.112	0.130
8.8	0.139	0.139	0.149	0.170	0.114	0.110	0.120	0.162
8.6	0.150	0.151	0.162	0.199	0.121	0.119	0.128	0.200
8.4	0.161	0.164	0.176	0.233	0.129	0.128	0.137	0.248
8.2	0.173	0.178	0.191	0.273	0.138	0.137	0.147	0.308
8.0	0.185	0.192	0.208	0.319	0.147	0.148	0.157	0.381
7.8	0.200	0.209	0.225	0.374	0.157	0.158	0.167	0.472
7.6	0.215	0.226	0.244	0.438	0.167	0.171	0.178	0.584
7.4	0.231	0.246	0.266	0.513	0.178	0.184	0.191	0.724
7.2	0.248	0.266	0.288	0.600	0.190	0.198	0.205	0.897
7.0	0.267	0.288	0.313	0.702	0.202	0.212	0.218	1.112
6.8	0.286	0.313	0.339	0.822	0.216	0.229	0.233	1.377

The magnitudes of the final catalogue were determined by means of the first solution for each plate, *i. e.*, they depend upon Vogel's photometrically determined magnitudes of twenty-five stars in the cluster χ Persei. We find in his list stars representing the entire range of magnitude of our photographs. The probable error of a single equation for this solution is only about two thirds as great as for the second, although, owing to the comparatively few standards used, those of a and b are greater.

The images of Plate 18 were less sharply defined than those of Plate 15, but they were more nearly circular, and we have given equal weight to the results of the two plates except where images are marked in Table VIII as "elongated" or "nebulous."

A notable instance of the difference between photographic and visual magnitudes is found in the case of the star B. D. 56° 547. Its visual magnitude is given by several observers as from 7.6 to 8.2, and it is one of the stars (*h*) selected by Schur for his heliometric triangulation. It is not found upon the Rutherford photographs, but is included in the list of stars measured by Ball and Rambaut¹ upon a plate exposed 10 minutes. Its photographic magnitude is not given, however. The star appears as of 9.4 magnitude upon two plates taken by Donner at Helsingfors,² with an exposure time of 20 minutes. We may conclude from this that it is only about one fourth as bright photographically as visually. Pihl³ mentions the decidedly yellow color of the star.

A few other stars given in the Bonn *Durchmusterung* as above the ninth magnitude are also missing. We give below a list of these with their B. D. numbers and magnitudes and also their photographic magnitudes as determined from Donner's plates.

B. D.		
No.	Mag.	Phot. Mag.
56° 497	8.9	9.0
56 547	8.2	9.4 (<i>h</i> of Schur's triangulation)
56 551	8.2	9.8
56 583	8.6	10.0
56 595	8.5	Nebulous
56 597	8.6	10.2

The first three of the list were found by Kapteyn and de Sitter⁴ to be of magnitudes from 9.6 to 10.0 upon plates pre-

¹ Sir Robert Ball and Arthur Rambaut. On the Relative Positions of 223 Stars in the Cluster χ Persei. *Trans. Roy. Irish Acad.* Vol. 30, Pt. 4, 1893.

² M. Bronsky and A. Stebnitzky, Les positions des étoiles de *h* et χ Persei. *Mémoires de l'académie impériale des sciences de St. Pétersbourg. Series VIII*, 1895.

³ O. A. L. Pihl. The Stellar Cluster χ Persei.

⁴ See Parallaxes of the Clusters *h* and χ Persei. *Pub. Astron. Lab. at Groningen*, No. 10, 1902.

pared by Donner for parallax determinations; images of the fourth and fifth were too faint or diffuse for measurement, and no trace of the last was found.

It is also of interest to note that of two stars designated by Vogel as of reddish hue, one, B. D. $56^{\circ} 563$, appears upon the photographs with a magnitude nearly the same as that given by Vogel, while the other, B. D. $56^{\circ} 583$, of visual magnitude 8.6 has a photographic magnitude of 10.0. A similar difference was noted by Lohse.¹

Eight stars of our catalogue are not found in the *Durchmusterung*. With a single exception, No. 106, these are found to be photographically of the ninth magnitude, or less.

¹ *Astron. Nach.*, 2649-50.

TABLE X.—FINAL CATALOGUE.

No.	Mag.	No. of Plates.	Right Ascension 1890.0				Precession.		Secular Variation.		Declination 1890.0	Precession.	Secular Variation.	Mean Epoch.			
			In Time.		In Arc.		In Time.	In Arc.	In Time.	In Arc.							
			h	m	s	°	'	"	s	"	s	"					
1	9.0	11	2	6	5.036	31	31	15.53	+4.1487	+62.2300	+0.0737	+1.1058	56° 59' 49.57"	17.0941	0.3237	1874.37	
2	9.1	4	7	23	695	31	50	55.43	4.1213	61.8188	0.0707	1.0612	56 4 22.68	17.0339	0.3245	74.42	
3	8.8	12	7	27	278	31	51	49.16	4.1352	62.0282	0.0719	1.0784	56 24 42.67	17.0311	0.3257	74.41	
4	8.1	12	7	55	847	31	58	57.70	4.1733	62.6002	0.0749	1.1232	57 14 57.95	17.0090	0.3297	74.41	
5	9.2	12	8	5	477	32	1	22.15	4.1602	62.4035	0.0737	1.1057	56 54 24.97	17.0016	0.3290	74.41	
6	8.7	12	8	20	601	32	5	9.02	+4.1758	+62.6365	+0.0748	+1.1226	57 13 53.83	+16.9899	—	0.3308	74.41
7	9.5	8	8	29	570	32	7	23.54	4.1715	62.5724	0.0744	1.1155	57 6 10.97	16.9830	0.3308	74.31	
8	9.0	8	8	49	863	32	12	27.94	4.1279	61.9190	0.0705	1.0569	55 58 32.08	16.9672	0.3282	74.42	
9	8.0	12	8	59	608	32	14	54.11	4.1391	62.0867	0.0713	1.0696	56 13 31.26	16.9597	0.3294	74.41	
10	7.4	12	9	5	348	32	16	20.22	4.1517	62.2752	0.0724	1.0856	56 31 1.47	16.9552	0.3306	74.41	
11	6.8	12	9	10	491	32	17	37.37	+4.1534	+62.3006	+0.0724	+1.0860	56 32 35.15	+16.9512	—	0.3309	74.41
12	9.4	12	9	12	619	32	18	9.28	4.1461	62.1918	0.0718	1.0765	56 21 31.70	16.9495	0.3304	74.41	
13	8.8	12	9	16	036	32	19	0.54	4.1572	62.3575	0.0727	1.0900	56 37 5.47	16.9468	0.3314	74.41	
14	7.5	12	9	17	809	32	19	27.13	4.1406	62.1091	0.0713	1.0688	56 12 24.45	16.9454	0.3302	74.41	
15	9.4	9	9	18	682	32	19	40.23	4.1562	62.3435	0.0726	1.0884	56 35 15.74	16.9448	0.3314	74.45	
16	9.4	4	9	23	262	32	20	48.93	+4.1436	+62.1539	+0.0710	+1.0652	56 15 50.73	+16.9412	—	0.3306	74.42
17	9.7	11	9	23	484	32	20	52.26	4.1514	62.2717	0.0721	1.0816	56 27 24.49	16.9410	0.3312	74.44	
18	8.4	12	9	28	067	32	22	1.01	4.1439	62.1590	0.0714	1.0714	56 15 28.77	16.9375	0.3308	74.41	
19	8.9	11	9	34	726	32	23	40.88	4.1500	62.2496	0.0719	1.0780	56 23 11.16	16.9323	0.3315	74.37	
20	8.0	12	9	44	670	32	26	10.05	4.1706	62.5584	0.0735	1.1027	56 51 17.07	16.9245	0.3335	74.41	
21	9.4	12	9	53	146	32	28	17.19	+4.1600	+62.3995	+0.0725	+1.0879	56 34 28.38	+16.9178	—	0.3330	74.41
22	9.0	11	9	56	568	32	29	8.52	4.1651	62.4768	0.0729	1.0939	56 41 17.95	16.9151	0.3335	74.37	
23	9.5	11	10	3	409	32	30	51.14	4.1536	62.3044	0.0709	1.0784	56 23 20.91	16.9098	0.3329	74.45	
24	9.4	10	10	4	683	32	31	10.25	4.1747	62.6205	0.0737	1.1049	56 53 35.65	16.9088	0.3346	74.41	
25	8.1	12	10	6	279	32	31	34.19	4.1435	62.1519	0.0710	1.0652	56 7 50.14	16.9076	0.3322	74.41	

TABLE X.—FINAL CATALOGUE.—Continued.

No.	Mag.	P ₁ Q ₁ N ₁	Right Ascension 1890.0			Precession.		Secular Variation.		Declination 1890.0	Precession.	Secular Variation.	Mean Epoch.
			In Time.	In Arc.	In Arc.	In Time.	In Arc.	In Time.	In Arc.				
			^h ^m ^s	[°] ['] ^{''}	^{''}	^s	^{''}	^s	^{''}	[°] ['] ^{''}	^{''}	^{''}	
26	8.8	12	10 7.650	32 37 54.74	+62.499	+4.1620	+62.499	+0.0726	+1.0883	56 34 46.82	+16.9065	-0.3337	1874.41
27	7.1	12	10 12.750	32 33 11.26	62.9529	+4.1969	62.9529	0.0755	1.1320	57 23 20.66	16.9025	0.3366	74.41
28	7.2	12	10 20.388	32 35 5.82	62.714	+4.1814	62.714	0.0741	1.1110	57 0 21.35	16.8965	0.3357	74.41
29	8.5	12	10 25.116	32 36 16.75	62.0889	+4.1393	62.0889	0.0705	1.0572	55 58 8.68	16.8927	0.3325	74.41
30	9.4	12	10 29.732	32 37 25.98	62.6392	+4.1759	62.6392	0.0735	1.1026	56 50 54.13	16.8892	0.3356	74.41
31	9.2	12	10 30.762	32 37 41.43	+62.7254	+4.1817	62.7254	+0.0740	+1.1097	56 58 52.31	+16.8883	-0.3361	74.41
32	8.6	12	10 31.865	32 37 57.97	62.9367	+4.1958	62.9367	0.0752	1.1276	57 18 27.01	16.8875	0.3372	74.41
33	9.1	11	10 32.172	32 38 2.58	62.5264	+4.1684	62.5264	0.0728	1.0927	56 39 39.54	16.8872	0.3351	74.45
34	9.2	7	10 33.953	32 38 29.29	62.5530	+4.1702	62.5530	0.0730	1.0947	56 41 54.73	16.8858	0.3353	74.22
35	9.2	4	10 36.186	32 39 2.79	62.5750	+4.1717	62.5750	0.0713	1.0692	56 43 37.47	16.8841	0.3355	74.40
36	9.2	12	10 36.880	32 39 13.20	+62.3363	+4.1558	62.3363	+0.0717	+1.0760	56 20 26.00	+16.8835	-0.3343	74.41
37	9.2	12	10 39.022	32 39 45.33	62.3528	+4.1575	62.3528	0.0719	1.0780	56 22 37.70	16.8818	0.3345	74.41
38	8.8	12	10 39.226	32 39 48.39	62.1678	+4.1445	62.1678	0.0708	1.0617	56 3 27.30	16.8817	0.3335	74.41
39	8.2	12	10 40.777	32 40 11.66	62.4422	+4.1628	62.4422	0.0723	1.0843	56 30 0.92	16.8804	0.3350	74.41
40	8.1	12	10 44.888	32 41 13.32	62.5734	+4.1716	62.5734	0.0730	1.0948	56 41 54.81	16.8772	0.3358	74.41
41	9.4	6	10 45.855	32 41 27.82	+62.6748	+4.1783	62.6748	+0.0735	+1.1032	56 51 24.35	+16.8764	-0.3364	74.27
42	9.0	12	10 46.800	32 41 42.00	62.5411	+4.1694	62.5411	0.0716	1.0740	56 38 27.94	16.8757	0.3357	74.41
43	9.0	12	10 47.007	32 41 45.10	62.7992	+4.1866	62.7992	0.0742	1.1135	57 2 55.77	16.8755	0.3371	74.41
44	9.0	12	10 49.435	32 42 21.52	62.5838	+4.1723	62.5838	0.0742	1.1131	56 42 4.71	16.8736	0.3360	74.41
45	9.1	9	10 53.160	32 43 17.40	62.3796	+4.1586	62.3796	0.0718	1.0772	56 21 44.30	16.8707	0.3351	74.27
46	9.2	12	10 57.378	32 44 20.66	+62.5297	+4.1686	62.5297	+0.0726	+1.0892	56 35 28.83	+16.8673	-0.3360	74.41
47	8.2	12	10 59.450	32 44 51.76	62.0895	+4.1393	62.0895	0.0701	1.0522	55 51 59.75	16.8657	0.3338	74.41
48	8.8	12	11 0.514	32 45 7.71	62.3254	+4.1550	62.3254	0.0714	1.0716	56 15 6.62	16.8649	0.3351	74.41
49	9.0	12	11 4.108	32 46 1.61	62.6582	+4.1772	62.6582	0.0733	1.0990	56 46 34.27	16.8620	0.3370	74.41
50	9.0	12	11 4.574	32 46 8.61	62.5647	+4.1710	62.5647	0.0727	1.0910	56 37 33.05	16.8617	0.3365	74.41

TABLE X.—FINAL CATALOGUE.—Continued.

No.	Mag.	No. of Plates.	Right Ascension 1890.0		Precession.		Secular Variation.		Declination 1890.0	Precession.	Secular Variation.	Mean Epoch.
			In Time.	In Arc.	In Time.	In Arc.	In Time.	In Arc.				
51	9.4	12	2 II 4.669	32 46 10.03	+ 4.1754	+ 62.6307	+ 0.0731	+ 1.0966	56 43 51.31	+ 16.8616	— 0.3368	1874.41
52	8.8	12	II 5.062	32 46 15.92	4.1682	62.5232	0.0725	1.0875	56 33 28.57	16.8613	0.3363	74.41
53	9.2	11	II 6.442	32 46 36.64	4.1696	62.5445	0.0726	1.0890	56 35 16.53	16.8602	0.3364	74.37
54	9.1	12	II 10.566	32 47 38.48	4.1719	62.5785	0.0728	1.0913	56 37 49.18	16.8569	0.3368	74.41
55	9.5	4	II 10.921	32 47 43.81	4.1727	62.5909	0.0728	1.0922	56 38 56.41	16.8567	0.3368	74.42
56	9.2	10	II 15.589	32 48 53.83	+ 4.1728	+ 62.5916	+ 0.0728	+ 1.0916	56 38 9.61	+ 16.8330	— 0.3370	74.50
57	9.1	11	II 16.784	32 49 11.76	4.1729	62.5942	0.0728	1.0916	56 38 11.67	16.8520	0.3371	74.45
58	9.6	2	II 17.306	32 49 19.59	4.1700	62.5505	0.0725	1.0879	56 33 54.98	16.8516	0.3369	74.42
59	9.5	3	II 18.131	32 49 31.96	4.1745	62.6174	0.0729	1.0934	56 40 10.81	16.8510	0.3372	74.54
60	6.9	12	II 21.048	32 50 15.72	4.1731	62.5958	0.0727	1.0912	56 37 35.64	16.8487	0.3372	74.41
61	9.2	12	II 23.027	32 50 45.40	+ 4.1729	+ 62.5935	+ 0.0727	+ 1.0907	56 37 1.82	+ 16.8471	— 0.3373	74.41
62	9.1	11	II 25.762	32 51 26.42	4.1736	62.6044	0.0727	1.0912	56 37 34.61	16.8449	0.3375	74.45
63	9.0	12	II 26.861	32 51 42.92	4.1734	62.6014	0.0727	1.0908	56 37 5.88	16.8441	0.3375	74.41
64	8.7	12	II 26.970	32 51 44.55	4.1736	62.6037	0.0727	1.0909	56 37 18.49	16.8440	0.3375	74.41
65	9.2	12	II 27.093	32 51 55.40	4.1693	62.5389	0.0724	1.0854	56 30 58.22	16.8435	0.3372	74.41
66	9.2	5	II 30.147	32 52 32.21	+ 4.1739	+ 62.6085	+ 0.0727	+ 1.0908	56 37 12.13	+ 16.8415	— 0.3376	74.49
67	7.0	12	II 30.242	32 52 33.63	4.1756	62.6342	0.0729	1.0930	56 39 37.89	16.8414	0.3378	74.41
68	9.3	4	II 33.444	32 53 21.66	4.1794	62.6908	0.0731	1.0972	56 44 26.62	16.8388	0.3382	74.42
69	9.2	12	II 43.958	32 55 45.87	4.1734	62.6011	0.0726	1.0883	56 34 11.96	16.8312	0.3381	74.41
70	9.2	12	II 43.716	32 55 55.74	4.1760	62.6399	0.0728	1.0914	56 37 47.49	16.8307	0.3383	74.41
71	9.0	11	II 54.410	32 58 36.15	+ 4.2001	+ 63.0021	+ 0.0747	+ 1.1203	57 9 57.10	+ 16.8222	— 0.3406	74.45
72	9.4	7	II 54.587	32 58 38.80	4.1829	62.7438	0.0732	1.0985	56 45 44.00	16.8221	0.3393	74.35
73	9.1	12	II 54.968	32 58 44.53	4.1928	62.8955	0.0741	1.1109	56 59 39.08	16.8218	0.3401	74.41
74	9.2	12	II 56.376	32 59 5.64	4.1756	62.6346	0.0726	1.0891	56 35 2.16	16.8207	0.3388	74.41
75	9.2	9	II 59.312	32 59 49.68	4.1604	62.4063	0.0713	1.0697	56 12 29.66	16.8183	0.3376	74.36

TABLE X.—FINAL CATALOGUE.—Continued

No.	Mag.	P ^h α ^o N	Right Ascension 1890.0		Precession.		Secular Variation.		Declination 1890.0	Precession.	Secular Vari- ation.	Mean Epoch.
			In Time. h m s	In Arc. ° ′ ″	In Time. s	In Arc. ″	In Time. s	In Arc. ″				
76	9.4	8	12 11 59.451	32 59 51.77	+ 4.1713	+ 62.5698	+ 0.0722	+ 1.0832	56° 28' 17.14"	+ 16.8182	— 0.3388	1874.39
77	9.2	8	12 6.008	33 1 30.12	4.1473	62.2095	0.0702	1.0525	55 51 58.95	16.8130	0.3369	74.31
78	8.0	12	12 11.164	33 2 47.46	4.1870	62.8056	0.0734	1.1011	56 48 38.10	16.8089	0.3402	74.41
79	9.2	10	12 20.924	33 5 13.86	4.1580	62.3993	0.0709	1.0635	56 5 3.24	16.8012	0.3382	74.32
80	9.4	7	12 24.514	33 6 7.72	4.1950	62.9254	0.0739	1.1092	56 57 32.08	16.7983	0.3313	74.38
81	9.2	8	12 31.020	33 7 45.30	+ 4.1653	+ 62.4793	+ 0.0714	+ 1.0711	56 13 58.07	+ 16.7932	— 0.3392	74.30
82	8.8	12	12 31.514	33 7 52.71	4.1803	62.7044	0.0726	1.0896	56 35 29.10	16.7927	0.3404	74.41
83	8.4	10	12 51.029	33 12 45.44	4.2132	63.1976	0.0751	1.1267	57 18 2.29	16.7772	0.3432	74.49
84	8.1	5	12 53.266	33 13 19.00	4.1512	62.2685	0.0700	1.0499	55 49 23.54	16.7754	0.3389	74.47
85	9.0	12	12 53.511	33 13 22.66	4.1921	62.8812	0.0734	1.1010	56 48 18.85	16.7752	0.3422	74.41
86	9.3	12	13 6.275	33 16 34.12	+ 4.1999	+ 62.9987	+ 0.0739	+ 1.1089	56 57 3.64	+ 16.7650	— 0.3433	74.41
87	9.0	12	13 8.993	33 17 14.90	4.1777	62.6652	0.0718	1.0775	56 25 10.15	16.7628	0.3416	74.41
88	9.0	12	13 22.439	33 20 36.58	4.1895	62.8427	0.0729	1.0935	56 39 39.15	16.7520	0.3430	74.41
89	9.2	12	13 25.723	33 21 25.85	4.1752	62.6278	0.0717	1.0782	56 18 39.13	16.7494	0.3420	74.41
90	8.5	12	13 26.597	33 21 38.95	4.1773	62.6601	0.0719	1.0778	56 21 35.32	16.7487	0.3422	74.41
91	9.2	12	13 27.801	33 21 57.02	+ 4.1770	+ 62.6549	+ 0.0717	+ 1.0758	56 20 53.21	+ 16.7477	— 0.3422	74.41
92	9.4	12	13 31.767	33 22 56.50	4.1898	62.8464	0.0728	1.0924	56 38 22.21	16.7445	0.3434	74.41
93	9.2	8	13 32.047	33 23 0.70	4.1967	62.9499	0.0734	1.1009	56 48 1.72	16.7443	0.3440	74.31
94	9.2	10	13 45.232	33 26 18.47	4.2096	63.1447	0.0743	1.1151	57 3 47.93	16.7337	0.3455	74.33
95	9.3	11	13 49.477	33 27 22.16	4.1984	62.9762	0.0734	1.1005	56 47 28.46	16.7303	0.3447	74.37
96	9.4	5	13 56.547	33 29 8.20	+ 4.1998	+ 62.9972	+ 0.0734	+ 1.1012	56 48 12.34	+ 16.7247	— 0.3451	74.34
97	9.0	12	13 57.885	33 29 28.28	4.1922	62.8827	0.0728	1.0915	56 37 14.74	16.7236	0.3445	74.41
98	9.8	4	14 1.122	33 30 16.82	4.1858	62.7870	0.0722	1.0831	56 27 38.88	16.7210	0.3442	74.21
99	8.8	12	14 3.939	33 30 59.09	4.2041	63.0615	0.0737	1.1054	56 52 54.23	16.7187	0.3457	74.41
100	9.3	9	14 7.096	33 31 46.43	4.1951	62.9259	0.0729	1.0937	56 39 41.63	16.7161	0.3451	74.46

TABLE X.—FINAL CATALOGUE.—Continued.

No.	Mag.	Plates.	Right Ascension 1890.0				Precession.		Secular Variation.		Declination 1890.0	Precession.	Secular Variation.	Mean Epoch.
							In Time.	In Arc.	In Time.	In Arc.				
			h	m	s	°	'	"	s	"				
101	9.0	7	2	14	7.303	33	31	49.55	+4.1703	+62.5538	56	4	14.84	1874.35
102	8.3	12	14	7.826	33	31	57.39	4.1841	0.0720	1.0800	56	24	0.97	0.3442
103	6.8	12	14	9.201	33	32	18.01	4.1986	0.0732	1.0977	56	44	17.57	0.3455
104	9.3	3	14	10.628	33	32	39.42	4.2029	0.0735	1.1029	56	50	4.83	0.3459
105	10.1	2	14	10.872	33	32	43.08	4.1763	0.0713	1.0700	56	12	23.91	0.3437
106	8.6	7	14	12.920	33	33	13.79	+4.1645	+0.0704	+1.0553	55	54	51.66	74.05
107	8.2	12	14	14.741	33	33	41.09	4.1951	0.0728	1.0926	56	38	25.34	74.36
108	9.1	12	14	15.130	33	33	46.94	4.1948	0.0728	1.0922	56	37	57.84	74.41
109	9.6	11	14	16.936	33	34	14.03	4.1952	0.0728	1.0923	56	38	8.65	74.41
110	9.2	12	14	20.785	33	35	11.78	4.1935	0.0726	1.0897	56	35	9.02	74.37
111	9.0	11	14	20.868	33	35	13.03	+4.1698	+0.0707	+1.0606	56	1	10.59	74.41
112	8.4	12	14	21.614	33	35	24.21	4.1945	0.0727	1.0908	56	36	26.32	74.37
113	9.0	12	14	22.729	33	35	40.93	4.1952	0.0728	1.0915	56	37	12.53	74.41
114	9.1	5	14	23.528	33	35	52.92	4.1734	0.0710	1.0646	56	5	58.97	74.41
115	9.2	12	14	23.877	33	35	58.16	4.1950	0.0727	1.0912	56	36	46.59	74.33
116	8.8	12	14	30.293	33	37	34.39	+4.2025	+0.0733	+1.0994	56	46	3.88	74.41
117	9.2	7	14	30.853	33	37	42.80	4.2177	0.0745	1.1182	57	6	57.66	74.23
118	9.1	12	14	31.735	33	37	56.03	4.1963	0.0728	1.0915	56	37	9.63	74.41
119	9.3	11	14	35.942	33	38	59.12	4.2037	0.0733	1.1001	56	46	50.48	74.37
120	9.2	12	14	43.309	33	40	49.64	4.2013	0.0730	1.0953	56	42	14.93	74.41
121	9.3	10	14	50.288	33	42	34.32	+4.1968	+0.0726	+1.0894	56	34	41.01	74.41
122	8.8	12	14	57.396	33	44	20.94	4.1979	0.0726	1.0897	56	34	59.81	74.41
123	8.7	12	15	1.562	33	45	23.43	4.2168	0.0742	1.1124	57	0	30.01	74.41
124	9.3	10	15	2.442	33	45	36.62	4.2014	0.0729	1.0932	56	39	1.78	74.32
125	7.8	12	15	6.466	33	46	36.99	4.2058	0.0732	1.0981	56	44	30.73	74.41

TABLE X.—FINAL CATALOGUE.—*Concluded.*

No.	Mag.	No. of Plates.	Right Ascension 1890.0		Precession.		Secular Variation.		Declination 1890.0	Precession.	Secular Variation.	Mean Epoch.
			In Time.	In Arc.	In Time.	In Arc.	In Time.	In Arc.				
126	9.0	8	15 10.179 h m s	33 47 32.69 ° ' ''	+4.1799 s	+62.6981 ''	+0.0710 s	+1.0656 ''	56 30 36.78 ° ' ''	+16.6652 ''	-0.3462 ''	1874.43
127	9.2	12	15 10.749	33 47 41.23	4.1964	62.9461	0.0724	1.0859	56 30 36.78	16.6647	0.3476	74.41
128	7.2	12	15 12.623	33 48 9.34	4.2127	63.1909	0.0737	1.1037	56 53 2.09	16.6632	0.3490	74.41
129	9.4	5	15 17.580	33 49 23.70	4.2021	63.0319	0.0728	1.0919	56 37 27.89	16.6591	0.3483	74.49
130	9.0	12	15 23.383	33 50 50.74	4.2178	63.2667	0.0740	1.1103	56 58 9.17	16.6544	0.3498	74.41
131	8.9	12	15 24.699	33 51 10.48	+4.2049	+63.0739	+0.0729	+1.0942	56 40 9.59	+16.6534	-0.3488	74.41
132	9.0	6	15 30.434	33 52 36.51	4.2210	63.3144	0.0742	1.1132	57 1 17.88	16.6487	0.3503	74.28
133	8.2	12	15 38.355	33 54 35.32	4.1930	62.8955	0.0718	1.0777	56 21 6.76	16.6423	0.3483	74.41
134	9.0	6	15 47.019	33 56 45.29	4.2097	63.1451	0.0731	1.0968	56 42 55.93	16.6352	0.3500	74.43
135	9.0	8	15 51.049	33 57 45.74	4.1828	62.7418	0.0714	1.0701	56 4 20.06	16.6320	0.3479	74.41
136	9.0	12	15 51.218	33 57 48.26	+4.1957	+62.9355	+0.0715	+1.0723	56 22 41.59	+16.6318	-0.3490	74.41
137	7.4	3	16 2.352	34 0 35.28	4.2394	63.5907	0.0754	1.1312	57 20 49.11	16.6227	0.3530	73.99
138	8.9	2	16 9.592	34 2 23.88	4.2133	63.1996	0.0732	1.0978	56 44 8.13	16.6168	0.3511	74.05
139	8.8	7	16 13.357	34 3 20.36	4.2161	63.2410	0.0734	1.1007	56 47 18.49	16.6137	0.3514	74.24
140	8.9	12	16 13.747	34 3 26.20	4.2189	63.2834	0.0736	1.1041	56 51 8.59	16.6134	0.3517	74.41
141	8.7	5	16 27.303	34 6 49.54	+4.1880	+62.8201	+0.0710	+1.0645	56 5 35.51	+16.6023	-0.3497	74.34
142	8.2	3	16 38.502	34 9 37.54	4.2382	63.5725	0.0743	1.1141	57 13 7.24	16.5932	0.3582	73.99
143	8.5	12	16 50.776	34 12 41.63	4.2175	63.2627	0.0727	1.0900	56 42 58.07	16.5831	0.3530	74.41
144	9.0	4	16 56.430	34 14 6.44	4.2085	63.1276	0.0723	1.0850	56 29 31.96	16.5784	0.3524	74.40
145	8.4	10	16 56.690	34 14 10.36	4.2291	63.4365	0.0740	1.1102	56 57 49.57	16.5781	0.3541	74.32

VIII. COMPARISON OF RESULTS.

Various measures have been made for determining relative positions of stars in these two clusters; some observers deal with one cluster only, others with both.

The following are micrometric surveys:

Lamont, "*Der Sternhaufen κ Persei*." *Annalen der Königlichen Sternwarte bei München*. Bd. XVII, München, 1869. Observations of position angles chiefly. These were reduced and discussed by Oertel at a later date, but no satisfactory results were obtained.

Bredichin, "*Mesures micrometriques du groupe de Persée*." *Annales de l'Observatoire de Moscou*. Vol. IV, 2 livraison. Approximate positions of sixty-five stars in κ Persei.

H. C. Vogel, "*Der Sternhaufen κ Persei beobachtet am 8-zölligen Refractor der Leipziger Sternwarte in den Jahren 1867-1870*." Leipzig, 1878. A catalogue of thirty of the brighter stars of the cluster. Differences of right ascension and declination are also recorded for 146 fainter stars, but they are determined with less precision. Magnitudes were measured with a Zöllner photometer and were used as fundamental for our final catalogue.

K. Oertel, "*Neue Beobachtungen und Ausmessung des Sternhaufens κ Persei am Münchener grossen Refractor*." *Neue Annalen der Königlichen Sternwarte in Bogenhausen bei München*. Bd. II, München, 1891. Observations of 125 stars made with the 10.5-inch refractor of the Munich observatory and reduced by the method of least squares. Lamont's earlier measures are also discussed.

O. A. L. Pihl, "The Stellar Cluster κ Persei Micrometrically Surveyed." Christiania, 1891. Measures made with the aid of a bar-micrometer attached to an equatorially mounted refractor of 3.25-inch aperture.

There are two sets of heliometer measures. These are:

A. Krüger, "*Der Sternhaufen κ Persei, Beobachtungen desselben am Bonner Heliometer nebst deren Berechnung*." Abdruck

aus den Abhandlungen der Finnischen Societät der Wissenschaften. Helsingfors, 1865. These measures are based upon the two stars B. D. $56^{\circ} 522$ and B. D. $56^{\circ} 530$. The results, reduced to 1875.0, are reprinted in the introduction to the Helsingfors-Gotha Zones of the A. G. Catalogue, with the statement that these places are more accurately determined than those of the same stars in the main catalogue.

W. Schur, "*Vermessung der beiden Sternhaufen η und χ Persei mit dem sechszölligen Heliometer der Sternwarte in Göttingen.*" *Astronomische Mittheilungen von der Königlichen Sternwarte zu Göttingen*. Göttingen, 1900. A careful triangulation of fifteen of the brightest stars of the clusters, using the two stars B. D. $56^{\circ} 471$ and $56^{\circ} 608$ for determining the orientation. The results were reduced to the A. G. C. system by comparison with observations made by Batterman with the Berlin meridian-circle, and the final catalogue is intended to serve as a basis for photographing the cluster. These are the fundamental star-places of our final catalogue.

There are two sets of photographic measures :

Sir Robert Ball and Arthur A. Rambaut, "On the Relative Position of 223 Stars in the Cluster χ Persei as determined Photographically." *Transactions of the Royal Irish Academy*, Vol. 30, Part 4, 1893. Differences of right ascension and declination are given for these stars as compared with B. D. $56^{\circ} 525$, determined from measures of a single plate. The main object of the paper is to illustrate a method of reducing photographic measures.

M. Bronsky and A. Stebnitzky, "*Les positions des étoiles de η et χ Persei et de leur environs déduites des mesures sur deux clichés photographiques.*" *Mémoires de l'académie impériale des sciences de St. Pétersbourg*. VIII^e Série, Tome II, 1895.

This catalogue contains positions of nearly 2,000 stars determined from measures of two photographs taken by Donner in Helsingfors, September 14, 1890, and September 20, 1892. More than 600 of these stars are found upon one plate only, the others are found upon both. For the first plate the telescope was directed toward χ Persei, for the second toward η .

The exposures were of 20 minutes duration, so that stars of the twelfth magnitude are included.

For convenience in comparison of catalogues Table XI has been prepared, giving our number for each star and the corresponding numbers in the various catalogues mentioned here. Numbers for stars found in the Bonn *Durchmusterung* and the *Astronomische Gesellschaft* Catalogue, Zones 55° to 65° , are also given. Krüger's numbers and those of the last-named memoir are not included, as they will be found later in a comparison of star-places.

TABLE XI.—FOR COMPARISON OF CATALOGUES.

Star.	B.D.	A.G.C.	Vogel.	Oertel.	Phil.	Star.	B.D.	A.G.C.	Vogel.	Oertel.	Phil.
1	56° 452					53	56° 513			25	
2	55 549					54	56 515			14	
3	56 462	1997				55	56 516			16	
4	57 525	2009				56	56 519			12	
5	56 464					57	56 520			11	
6	57 527	2017				58				32	
7	56 466					59	56 521			29	
8	55 557					60	56 522	2088		1	
9	56 469	2027				61	56 524			2	
10	56 470	2028		63		62	56 525			5	
11	56 471	2030		62		63	56 526	2090		7	
12	56 472					64	56 527	2089		6	
13	56 473	2033		68		65	56 528			83	
14	56 475	2035				66	56 529			4	
15	56 476	2036		64		67	56 530	2093		19	
17	56 477					68	56 531			80	
18	56 478	2038				69	56 534	2100		44	
19	56 479	2043				70	56 535	2101		38	
20	56 480	2045				71	57 541	2103			
21	56 481			66		72	56 537			72	
22	56 482	2049		70		73	56 536				
23	56 484	2052				74	56 538	2106		21	
24	56 483					75	56 541				
25	55 564	2054				76	56 540			92	
26	56 485	2056		65		77	55 577				
27	57 535					78	56 543	2113		74	
28	56 486	2061				79	55 581	2115			
29	55 568	2064				80	56 544				
30	56 488					81	56 546				
31	56 487					82	56 545	2117		75	5
32	57 536	2067				83	57 545	2122			
33	56 489			48		84	55 587	2124			
34	56 491			54		85	56 548				17
35	56 492			56		86	56 549				
36	56 493					87	56 550				22
37	56 494					88	56 553		6		27
38	55 570	2069				89	56 554				32
39	56 498	2071		34		90	56 555	2137			33
40	56 500	2073		52		91	56 556	2138			35
42	56 501	2074		45		92	56 557		11		38
43	56 499					93	56 559		12		39
44	56 502	2076		53		94	56 560				
45	56 503					95	56 561		33		54
46	56 504	2078		27		96	56 562		39		61
47	55 571	2079				97	56 563		42		64
48	56 507					98	56 564				69
49	56 508	2080		71		99	56 565	2147			72
50	56 510			41		100	56 566		55		76
51	56 509	2082		57		101	55 594				
52	56 511	2083		30		102	56 567	2148			77

TABLE XI.—COMPARISON OF CATALOGUES.—*Concluded.*

Star.	B. D.	A. G. C.	Vogel.	Oertel.	Pihl.	Star.	B. D.	A. G. C.	Vogel.	Oertel.	Pihl.
103	56° 568	2150	56		78	125	56° 591	2175	139		144
104					81	126	55 600	2176			
105	56 569					127	56 592				149
107	56 570	2152	67		86	128	56 593	2177			150
108	56 571	2153	70		89	129					155
109	56 572	2154	72		91	130	56 594	2185			
110	56 573		79		96	131	56 596		163		160
111	55 596	2156				133	56 598	2190			171
112	56 574	2157	80		98	134	56 599		172		179
113	56 575	2158	82		100	135	55 605				
114	55 597	2160				136	56 600	2195			183
115	56 576	2159	86		102	137	57 554	2197			
116	56 577	2163	98		110	138	56 601				194
117	56 579					139	56 603				197
118	56 578	2164	100		112	140	56 602	2201			198
119	56 582	2165	109		119	141	55 607	2203			
120	56 584		119		122	142	57 559	2208			
121	56 586		125		127	143	56 605	2209			
122	56 588	2171	134		137	144					223
123	56 589	2172				145	56 606	2211			229
124	56 590		137		142						

Comparison with Krüger. — Thirty-seven stars of our catalogue were measured by Krüger with the heliometer, the mean epoch being 1862.5. The resulting positions were reduced to the mean equinox of 1890.0, and a comparison with ours is given in Table XII. The first column gives our catalogue numbers, the second gives Krüger's numbers, while in the third and fifth are found the direct differences of right ascension and declination. Krüger's position of our central star, No. 67, differs from Schur's by $+ 0^s.02$ in right ascension, $- 0''.01$ in declination, amounts almost identical with the corresponding mean differences. It would seem, therefore, that no rotation of axes was necessary to bring our results into close agreement with his, but that this would be accomplished by a simple translation of the origin of coördinates. The fourth and sixth columns give the differences corrected for this change of origin and the agreement between the two sets of measures is seen to be very good.

TABLE XII.—COMPARISON WITH KRÜGER'S HELIOMETER RESULTS.

Ruth. Ep. 1874.4	Kr. 1862.5	R. A.		Decl.	
		Direct Diff.	Corr. Diff.	Direct Diff.	Corr. Diff.
		^s	^s	["]	["]
10	19	+0.01	-0.01	+0.03	+0.04
11	18	+0.07	+0.05	-0.13	-0.12
13	34	+0.05	+0.03	-0.26	-0.25
19	32	+0.09	+0.07	-0.01	0.00
21	29	+0.03	+0.01	+0.07	+0.08
22	30	+0.03	+0.01	-0.35	-0.34
23	33	+0.11	+0.09	-0.15	-0.14
26	28	+0.02	0.00	+0.20	+0.21
33	27	+0.05	+0.03	-0.05	-0.04
34	42	+0.04	+0.02	-0.05	-0.04
39	5	+0.02	0.00	0.00	0.00
40	4	-0.01	-0.03	-0.32	-0.31
42	14	-0.04	-0.06	-0.11	-0.10
44	15	0.00	-0.02	-0.15	-0.14
46	6	+0.07	+0.05	-0.01	0.00
49	24	-0.04	-0.06	-0.28	-0.27
50	9	+0.02	-0.01	-0.04	-0.03
51	25	-0.08	-0.10	-0.15	-0.14
52	13	+0.05	+0.03	+0.04	+0.05
53	23	+0.12	+0.10	+0.04	+0.05
54	8	+0.01	-0.01	-0.15	-0.14
56	17	0.00	-0.02	+0.06	+0.07
57	16	+0.04	+0.02	+0.14	+0.15
60	1	0.00	-0.02	+0.28	+0.29
62	3	+0.00	-0.02	+0.12	+0.13
63	d	+0.01	-0.01	+0.02	+0.03
64	d	+0.01	-0.01	+0.11	+0.12
65	22	+0.04	+0.02	+0.11	+0.12
66	36	+0.02	0.00	+0.15	+0.16
67	2	+0.02	0.00	-0.01	0.00
69	11	+0.03	+0.01	+0.13	+0.14
70	7	+0.01	-0.01	+0.07	+0.08
72	35	-0.02	-0.04	+0.11	+0.12
74	21	-0.01	-0.03	-0.05	-0.04
76	44	-0.01	-0.03	-0.14	-0.13
78	12	+0.04	+0.02	+0.07	+0.08
82	26	0.00	-0.02	+0.11	+0.12

Mean Difference in R. A. $\overset{s}{+0.022} \pm \overset{s}{0.004}$.

Mean Difference in Decl. $\overset{''}{-0.01} \pm \overset{''}{0.016}$.

Comparison with Bronsky and Stebnitzky. — This catalogue contains nearly all our stars, but their positions are determined from measures of only two photographs and the plate constants depend upon star-places less accurately determined

than Schur's. The results are given separately for each plate, but in our comparison we have used the mean, excepting where the differences between the two are bracketed in the original catalogue because abnormally large. In such cases we have used the positions from the second plate, as according to the authors' statement these have been verified. The number of decimal places used in the comparison corresponds to that given in the Bronsky and Stebnitzky catalogue.

A direct comparison gave the arithmetical mean of the differences in right ascension $+ 0^s.061 \pm 0^s.003$, in declination, $- 0''.15 \pm 0''.02$. But in order to bring our results into the best possible agreement it may be necessary to change the scale-value and orientation as well as the zero-point. Such corrections were determined from a least squares solution of equations of the form

$$Xd\phi + Ydr + dk + du \cdot \cos \delta = 0,$$

$$Yd\phi - Xdr + dc + d\delta = 0,$$

where du and $d\delta$ are the direct differences in right ascension and declination. Each star common to the two catalogues would give a pair of such equations. We have omitted from the solution two stars found upon only one of the Helsingfors plates and four others where the differences between the two plates were bracketed in the original catalogue.

The corrections were found to be

$$d\phi = + 0.0000002 \pm 0.000012,$$

$$dr = + 0.000052 \pm 0.000012,$$

$$dk \sec \delta = - 0.058 \pm 0.002,$$

$$dc = + 0''.19 \pm 0''.021.$$

The change in scale-value was inappreciable even for the outermost stars. The change in orientation corresponds to a decrease of $10''.7$ in the position angle of all stars, and changes the coördinates of the most remote ones by $0''.14$. The right ascension of the origin was increased $0^s.058$, its declination decreased $0''.19$.

Applying these corrections to all stars common to the two catalogues the corrected differences found in the fourth and sixth columns of Table XIII were obtained. The uncorrected differences appear in the third and fifth columns.

TABLE XIII.—COMPARISON WITH BRONSKY AND STEBNITZKY.

Ruth. Ep. 1874.4	Br. and St. 1891.7	R. A.		Decl.	
		Direct Diff.	Corr. Diff.	Direct Diff.	Corr. Diff.
6	4	+0.02	—0.03	—0.3	0.0
7	15	+0.08	+0.04	+0.4	+0.7
8	44	+0.05	—0.02	—0.5	—0.3
9	58	+0.02	—0.04	—0.8	—0.6
10	65	+0.14	+0.07	—0.8	—0.5
11	76	+0.01	—0.05	+0.6	+0.9
12	81	+0.08	+0.01	—0.4	—0.2
13	85	+0.06	0.00	0.0	+0.2
14	86	+0.04	—0.03	—0.1	+0.2
15	88	+0.06	0.00	—0.6	—0.3
16	99	+0.09	+0.03	—0.1	+0.1
17	100	+0.05	—0.01	—0.6	—0.4
18	109	+0.08	+0.01	—0.5	—0.3
19	119	+0.06	0.00	0.0	+0.2
20	142	+0.10	+0.04	—0.6	—0.4
21	157	+0.04	—0.02	—0.4	—0.2
22	163	+0.09	+0.03	0.0	+0.2
23	176	+0.09	+0.02	—0.6	—0.4
24	181	+0.04	—0.01	0.0	+0.2
25	188	+0.08	0.00	0.0	+0.2
26	189	+0.04	—0.02	—0.2	+0.1
27	199	+0.18	+0.14	—0.2	0.0
28	216	—0.01	—0.06	+0.4	+0.6
29	232	+0.01	—0.06	—0.4	—0.2
30	254	+0.09	+0.03	0.0	+0.2
31	257	+0.08	+0.03	—0.2	0.0
32	264	+0.15	+0.10	—1.1	—0.8
33	265	+0.08	+0.02	—0.6	—0.4
34	269	+0.10	+0.04	—0.2	0.0
35	277	+0.07	+0.01	—0.2	0.0
36	282	+0.09	+0.02	—0.8	—0.6
37	285	+0.08	+0.01	—0.4	—0.2
38	290	+0.77	+0.70	—4.2	—4.0
39	293	+0.06	0.00	—0.1	+0.1
40	311	+0.06	0.00	0.0	+0.2
41	315	+0.02	—0.03	—0.6	—0.3
42	319	+0.10	+0.04	—0.6	—0.4
43	322	+0.11	+0.05	—0.2	0.0
44	329	+0.05	—0.01	—0.3	—0.1
45	341	+0.06	—0.01	—0.5	—0.3
46	353	+0.01	—0.05	—0.1	+0.1
47	360	+0.03	—0.05	—0.1	+0.1
48	365	+0.06	—0.01	—0.4	—0.2
49	379	+0.11	—0.05	—0.5	—0.3
50	381	+0.07	+0.01	+0.6	+0.2
51	382	+0.10	+0.04	—0.9	—0.7
52	385	+0.04	—0.02	0.0	+0.2
53	391	+0.03	—0.03	—0.1	+0.1
54	416	+0.08	+0.02	—0.3	—0.1
55	418	+0.05	0.00	—0.3	—0.1

TABLE XIII.—COMPARISON WITH BRONSKY AND STEBNITZKY.—
Continued.

Ruth. Ep. 1874.4.	Br. and St. 1891.7.	R. A.		Decl.	
		Direct Diff.	Corr. Diff.	Direct Diff.	Corr. Diff.
		s	s	"	"
56	437	+0.06	0.00	-0.8	-0.6
57	442	+0.18	+0.12	-0.3	-0.1
58	446	+0.05	-0.01	-0.3	-0.1
59	450	+0.03	-0.03	+0.6	+0.8
60	462	+0.02	-0.04	-0.2	0.0
61	472	+0.05	-0.01	+0.1	+0.3
62	487	+0.03	-0.02	-0.1	+0.1
63	496	+0.02	-0.04	-0.2	0.0
64	497	+0.05	-0.01	+0.3	+0.5
65	498	+0.05	-0.02	-0.2	0.0
66	503	+0.07	+0.01	0.0	+0.2
67	504	+0.06	0.00	-0.5	-0.4
68	518	+0.10	+0.04	-0.9	-0.7
69	546	+0.06	0.00	-0.5	-0.3
70	549	+0.07	+0.01	-0.2	-0.1
71	579	+0.10	+0.05	-0.2	0.0
72	581	-0.07	-0.12	-0.7	-0.5
73	583	+0.05	0.00	-0.1	+0.1
74	589	+0.12	+0.06	-0.4	-0.2
75	597	+0.12	+0.05	-0.3	-0.1
76	599	+0.15	+0.08	-0.4	-0.2
77	616	+0.11	+0.03	-0.4	-0.2
78	630	+0.03	-0.03	0.0	+0.1
79	641	+0.12	+0.04	-0.7	-0.6
80	648	+0.06	0.00	-0.4	-0.3
81	658	+0.04	-0.03	-0.5	-0.4
82	662	+0.03	-0.03	0.0	+0.2
83	692	0.00	-0.05	0.0	+0.2
84	696	+0.03	-0.05	0.0	+0.1
85	697	+0.03	-0.03	-0.1	+0.1
86	716	+0.08	+0.03	+0.5	+0.6
87	723	+0.06	0.00	0.0	+0.2
88	737	+0.07	+0.01	-0.1	0.0
89	743 ^a	+0.08	+0.02	-0.4	-0.2
90	744 ^a	+0.06	-0.01	0.0	+0.1
91	746 ^a	+0.09	+0.02	-0.1	0.0
92	754	+0.09	+0.03	+0.3	+0.5
93	755	+0.04	-0.02	0.0	+0.2
94	791	+0.03	-0.02	-0.2	0.0
95	796	+0.07	+0.01	+0.1	+0.2
96	809	+0.06	+0.01	-0.4	-0.3
97	817	+0.12	+0.06	0.0	+0.1
98	825	+0.09	+0.02	+0.2	+0.3
99	831	+0.04	-0.01	+0.1	+0.2
100	839	+0.03	-0.03	0.0	+0.1
101	1447	+0.07	0.00	-0.1	0.0
102	840	0.00	-0.06	-0.3	-0.2
103	843	+0.03	-0.02	+0.7	+0.8

TABLE XIII.—COMPARISON WITH BRONSKY AND STEBNITZKY.
Concluded.

Ruth. Ep. 1874.4	Br. and St. 1891.7	R. A.		Decl.	
		Direct Diff.	Corr. Diff.	Direct Diff.	Corr. Diff.
		^s	["]	["]	["]
104	847	+0.06	+0.01	-0.1	0.0
105	849	+0.14	+0.07	0.0	+0.2
106	854	+0.03	-0.04	0.0	+0.2
107	859	+0.02	-0.03	-0.2	-0.1
108	862	+0.04	-0.02	+0.5	+0.6
109	867	+0.07	+0.01	+0.2	+0.3
110	881	+0.06	0.00	-0.3	-0.2
111	882	+0.06	-0.01	0.0	+0.1
112	884	+0.03	-0.03	+0.3	+0.4
113	890	+0.07	+0.01	+0.2	+0.3
114	892	+0.06	-0.01	-0.2	-0.1
115	896	+0.05	-0.01	0.0	+0.1
116	916	+0.06	0.00	-0.4	-0.3
117	917	-0.01	-0.06	+0.3	+0.4
118	919	+0.03	-0.03	+0.3	+0.4
119	928	+0.07	+0.01	+0.2	+0.3
120	942	+0.09	+0.03	+0.5	+0.6
121	959	+0.07	+0.01	-0.3	-0.2
122	972	+0.05	-0.01	-0.2	-0.1
123	978	+0.03	-0.02	0.0	+0.1
124	979	+0.07	+0.01	+0.4	+0.5
125	982	0.00	-0.06	-0.4	-0.3
126	989	+0.04	-0.03	0.0	+0.1
127	991	0.00	-0.06	+0.1	+0.2
128	993	+0.02	-0.03	-0.1	0.0
129	1000	+0.08	+0.02	+0.1	+0.2
130	1007	+0.04	-0.02	-0.2	-0.1
131	1009	+0.05	-0.02	-0.2	-0.1
132	1012	+0.08	+0.03	+0.1	+0.2
133	1032	+0.05	-0.02	-0.2	-0.1
134	1049	+0.08	+0.02	-0.4	-0.3
135	1054	+0.03	-0.04	-0.4	-0.3
136	1056a	+0.19	+0.12	-0.9	-0.8
137	1070	+0.02	-0.02	+0.3	+0.4
138	1079	+0.03	-0.02	-0.1	0.0
139	1086	+0.01	-0.04	-0.2	-0.1
140	1088	+0.04	-0.01	0.0	0.0
141	1103	+0.01	-0.06	+0.8	+0.8
142	1116	+0.10	+0.06	+0.1	+0.2
143	1131	+0.05	-0.01	-0.6	-0.5
144	1140	+0.08	+0.02	-0.3	-0.3
145	1142	+0.06	0.00	+0.2	+0.2

Mean Difference in R. A. $\overset{s}{+0.061} \pm \overset{s}{0.003}$.

Mean Difference in Decl. $\overset{''}{-0.15} \pm \overset{''}{0.02}$.

The unusually large residuals resulting from the comparison of No. 38 with Bronsky and Stebnitzky No. 290, led us to doubt the identity of the two stars. They are of the same magnitude, however, and were evidently considered identical by Bronsky and Stebnitzky in their comparison with the A. G. Catalogue, where similar large residuals appear.

Two misprints were found in the catalogue and were corrected in making our comparison. The declination of No. 917 should read 57° instead of 56° , as will be seen by referring to the value of y for either plate. The declination of No. 381 as determined from Plate II should read $33''.4$ instead of $34''.4$. This is consistent with the value given in the table for the difference, II minus I, and with the comparison with other catalogue places given later in the memoir.

The corrected differences of Table XIII indicate a fairly good agreement between the two catalogues, considering the difference in the character of the two investigations and the undetermined effects of proper motion during the seventeen years between the two sets of photographs.

In conclusion I wish to express my appreciation of the efficient aid in computation rendered by Miss Harpham and her assistants, and my thanks to Professor Jacoby for many helpful suggestions and for securing the publication of the work.

ERRATA.

In Former Contributions from the Observatory of Columbia University. Continued from No. 19, p. 71.

No. 15. THE PRÆSEPE GROUP; MEASUREMENT AND REDUCTION OF THE RUTHERFURD PHOTOGRAPHS.

Page 257, star 17, for 48' read 58'.

Page 259, star 22, for 12' read 13'.

Page 259, star 23, for 34' read 24'.

(Corresponding changes should be made in the final catalogue on page 271.)

Page 263, insert $\pm$ sign before probable error.

Page 271, star 8, for B. D. mag. 9.0 read B. D. mag. 8.5.

No. 17. THE RUTHERFURD PHOTOGRAPHIC MEASURES OF THE GROUP OF THE PLEIADES. (Second paper.)

Page 23, star 15, for 29' read 28'.

No. 18. THE PARALLAX OF μ CASSIOPEIÆ AND THE POSITIONS OF 56 NEIGHBORING STARS AS DEDUCED FROM THE RUTHERFURD PHOTOGRAPHIC MEASURES.

Page 66, line 11 from bottom, for (5.062801-20) read (5.062801-10).

Page 88, star 29, for mean 2278.754 read 2778.754.

Page 100, interchange declinations of stars 1 and 2.

Page 100, star 10, for $3^{\circ}.03$ read $5^{\circ}.18$; for $55^{\circ} 6' 30''.9$ read $54^{\circ} 48' 17''.4$.

Page 100, star 11, for $55^{\circ}.07$ read $57^{\circ}.81$.

Page 100, star 31, in secular variation for .149 read .139.

Page 100, star 48, for $2^m 44^s.25$ read $3^m 17^s.83$; for $49' 21''.2$ read $43' 9''.1$.

Page 100, add $0^s.0032$ to all secular variations in right ascension.

No. 19. CATALOGUE OF 287 STARS NEAR THE SOUTH POLE, AND OPTICAL DISTORTION OF THE CAPE OF GOOD HOPE ASTRO-PHOTOGRAPHIC TELESCOPE.

Page 48, line 15, for $(\pm .02)$ read $(\pm .12)$.

Page 60, star 177, right ascension should read $230^{\circ} 16' 22''$.

No. 23. TABLES FOR THE REDUCTION OF ASTRONOMICAL PHOTOGRAPHS.

Page 11, line 10, for $+ [X]r$ read $- [X]r$.

Page 11, line 18, for $(p + N)Y'$ read $(p + N_y)Y'$.

VITA.

Anne Sewell Young was born in Bloomington, Wisconsin, January 2, 1871. She attended the public schools of New Lisbon, Wis., completing the High School course in 1886; entered Carleton College, Northfield, Minn., in 1888, receiving the degree of Bachelor of Literature in 1892. She has attended the following institutions for graduate work: Carleton College, from September, 1896, to December, 1897, receiving the degree of Master of Science; University of Chicago, from January to June, 1898, and from February to June, 1902; Columbia University, 1905-1906. She was Volunteer Research Assistant at Yerkes Observatory during the summer of 1902. From 1892 to 1895, she taught Mathematics in Whitman College, Walla Walla, Wash.; during the year 1898 to 1899 she was Principal of the High School at St. Charles, Ill.; in 1899 she became Instructor in Astronomy at Mount Holyoke College, where she has held a professorship since 1904.

Previous publications are: "Elliptic Elements of Comet *g*, 1896," *Astronomical Journal*, July, 1897; "The Sun's Heat," *Popular Astronomy*, May, 1898; "On the Density of the Solar Nebula," *Astrophysical Journal*, June, 1901.

LIST OF CONTRIBUTIONS FROM THE OBSERVATORY OF COLUMBIA UNIVERSITY, NEW YORK.

LISTS OF ERRATA IN CONTRIBUTIONS FROM THE OBSERVATORY OF COLUMBIA UNIVERSITY WILL BE FOUND IN CONTRIBUTIONS 19, p. 68, and 24, p. 74.

- No. 1. LEWIS MORRIS RUTHERFURD, BY JOHN K. REES. Pp. 15. July, 1906. *Octavo.*
- No. 2. A CATALOGUE OF RUTHERFURD'S PHOTOGRAPHIC PLATES OF THE SUN, THE MOON AND THE STARS, BY JOHN K. REES. Pp. 7. July, 1906. *Octavo.*
- No. 3. THE RUTHERFURD PHOTOGRAPHIC MEASURES OF THE GROUP OF THE PLEIADES, BY HAROLD JACOBY. Annals of the New York Academy of Sciences, Vol. VI., pp. 239-330. February, 1892. *Octavo.*
- No. 4. THE RUTHERFURD PHOTOGRAPHIC MEASURES OF THE STARS ABOUT β CYGNI, BY HAROLD JACOBY. Annals of the New York Academy of Sciences, Vol. VI., pp. 331-348. May, 1892. *Octavo.*
- No. 5. THE PARALLAXES OF μ AND θ CASSIOPEIÆ DEDUCED FROM RUTHERFURD PHOTOGRAPHIC MEASURES, BY HAROLD JACOBY. Annals of the New York Academy of Sciences, Vol. VIII., pp. 1-23. March, 1893. *Octavo.*
- No. 6. THE PARALLAX OF η CASSIOPEIÆ DEDUCED FROM THE RUTHERFURD PHOTOGRAPHIC MEASURES, BY HERMAN S. DAVIS. Annals of the New York Academy of Sciences, Vol. VIII., pp. 301-321. April, 1895. *Octavo.*
- No. 7. THE RUTHERFURD PHOTOGRAPHIC MEASURES OF SIXTY-TWO STARS ABOUT η CASSIOPEIÆ, BY HERMAN S. DAVIS. Annals of the New York Academy of Sciences, Vol. VIII., pp. 381-416. June, 1895. *Octavo.*
- No. 8. DECLINATIONS AND PROPER MOTIONS OF FIFTY-SIX STARS, BY HERMAN S. DAVIS, PH.D. Memoir I., Part 1, New York Academy of Sciences, pp. 105. June, 1895. *Quarto.*
- No. 9. THE VARIATION OF LATITUDE AT NEW YORK CITY FROM OBSERVATIONS BY JOHN K. REES, HAROLD JACOBY AND HERMAN S. DAVIS. MEMOIR I., Part 2, New York Academy of Sciences, pp. 236. July, 1906. *Quarto.*
- No. 10. ON THE REDUCTION OF STELLAR PHOTOGRAPHS, WITH SPECIAL REFERENCE TO THE ASTRO-PHOTOGRAPHIC CATALOGUE PLATES, BY HAROLD JACOBY. Annals of the New York Academy of Sciences, Vol. IX., pp. 101-123. April, 1896. *Octavo.*
- No. 11. ON THE PERMANENCE OF THE RUTHERFURD PHOTOGRAPHIC PLATES, BY HAROLD JACOBY. Annals of the New York Academy of Sciences, Vol. IX., pp. 195-284. October, 1896. *Octavo.*

- No. 12. THE RUTHERFURD PHOTOGRAPHIC MEASURES OF SIXTY-FIVE STARS NEAR 61 CYGNI, BY HERMAN S. DAVIS. *Annals of the New York Academy of Sciences*. Vol. X., pp. 58-121. August, 1897. *Octavo*.
- No. 13. THE PARALLAXES OF 61¹ AND 61² CYGNI DEDUCED FROM THE RUTHERFURD PHOTOGRAPHIC MEASURES, BY HERMAN S. DAVIS. *Annals of the New York Academy of Sciences*, Vol. X., pp. 123-160. August, 1897. *Octavo*.
- No. 14. THE RUTHERFURD PHOTOGRAPHIC MEASURES OF THIRTY-FOUR STARS NEAR "BRADLEY 3077," BY HERMAN S. DAVIS. *Annals of the New York Academy of Sciences*, Vol. X., pp. 161-187. August, 1897. *Octavo*.
- No. 15. THE PRÆSEPE GROUP; MEASUREMENT AND REDUCTION OF THE RUTHERFURD PHOTOGRAPHS, BY FRANK SCHLESINGER. *Annals of the New York Academy of Sciences*, Vol. X., pp. 188-286. May, 1898. *Octavo*.
- No. 16. THE POSITIONS AND PROPER MOTIONS OF THE PRINCIPAL STARS IN THE CLUSTER OF COMA BERENICES AS DEDUCED FROM MEASUREMENTS OF THE RUTHERFURD PHOTOGRAPHS, BY WALTER C. KRETZ. *Annals of the New York Academy of Sciences*, Vol. XII., pp. 342-478. February, 1900. *Octavo*.
- No. 17. THE RUTHERFURD PHOTOGRAPHIC MEASURES OF THE GROUP OF THE PLEIADES (Second Paper), BY HAROLD JACOBY. Pp. 24, January, 1901. *Octavo*.
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